CARDIORESPIRATORY FITNESS AND UNINTENTIONAL NONFATAL INJURY AMONG THE UNITED STATES AIR FORCE ACTIVE DUTY

by

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ABSTRACT

Statement of the Problem

Unintentional nonfatal injuries were the third leading cause of hospitalizations in the United States Air Force in 1992. The Air Force places great emphasis on the need for its personnel to maintain physical fitness as a key to supporting the demanding requirements of its worldwide missions. Despite current surveillance techniques, little extant literature explicates the degree to which cardiorespiratory fitness contributes to nonfatal unintentional injuries within the Air Force active duty (ADAF) population. Injury outcomes were examined in relation to cardiorespiratory fitness levels among the ADAF.

Methods

A case-control study design was used to explore the relationship between cardiorespiratory fitness and injuries among injured and non-injured USAF personnel in 1999 and 2000 (n = 72,730). Personnel who were injured in 2000 comprised the cases (n = 39,688); they must have completed a cycle ergometry fitness test in 2000 prior to the date of the injury. Controls (n = 33,042) were uninjured ADAF airmen who had been on active duty for at least one year, had a physical examination, and a cycle ergometry fitness assessment in 1999. Both multiple logistic regression and polychotomous logistic regression models were fitted to the data to examine the associations between cardiorespiratory fitness and injuries.

Results

Results from logistic regression modeling statistical analyses revealed a strong positive association between cardiorespiratory fitness and injuries: adjusted for other factors, the odds of injury for airmen who passed the fitness assessment was 1.62 (95% CI; 1.55, 1.68). Increase in body mass index (BMI) was associated with increased odds for injury (OR: 1.20; 95% CI: 1.17, 1.24). The findings provided negligible support for the relationship of tobacco use and injuries.

Conclusion

These results should provide a basis for directing future research efforts at understanding the relationship of cardiorespiratory fitness, physical activity with unintentional nonfatal injuries among the military. The study's findings have important implications for the military medical and safety communities in coordinating and enforcing injury surveillance and prevention policies.

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CHAPTER 1. INTRODUCTION AND STATEMENT OF THE PROBLEM

Introduction to the Problem

Unintentional injuries constitute a major public health problem in the United States. They are the leading cause of mortality among young adults aged 15 – 34 yrs and the third leading cause of deaths among adults aged 35 – 54 years (Bonnie RG, Fulco CE, and Liverman CT, 1999). In 1996 alone, injuries resulted in nearly 2,000 years of potential life lost before age 75, and cost the nation $260 billion (Bonnie et al., 1999). Despite nonfatal injury morbidity rates being ambiguously defined, researchers estimate that every year (1999) nearly 25 percent of the U.S. population sustains an injury (Smith GS, Wellman HM, Sorock GS, Warner M, Courtney TK, Pransky GS, Fingerhut LA, 2005). Injuries have been successfully quantified in terms of mortality. However, neither injury morbidity nor their accompanying costs, which account for the significant erosion of the quality-of-life incurred by those severely injured and their families, nor the additional economic burden sustained by the entire society have been adequately documented (Leigh JP, Markowitz SB, Fahs M, Shin C, Landrigan PJ, 1997).

Most injuries are not the result of apparent coincidence. Rather, they are predictable based on the nature of various innate individual (e.g., age, gender, behavior, etc.) and inherent environmental (e.g., occupation, geography, weather, etc.) risk factors that exist within any population or region of the world. The relationships between injuries and some risk factors have been investigated within the U.S., such as high-risk occupations (e.g., trucking, lumber and mining industries), obesity, cigarette smoking, physical activity, age, race and gender, while the possible effects of other risk factors are less well known. For example, the prevalence of obesity (Body Mass Index [BMI] ≥ 30 kg/m^2) among U.S. adults over the past three decades has continued to grow at a rate that now exceeds 20 percent (Institute of Medicine [IOM] 2003). Some studies have demonstrated that the risk for injury-related disability increases as BMI increases (Kwiatskowski TC, Hanley EN, Ramp WK, 1996; Mäkelä M. Heliövaara M, Sievers K,

et al, 1993; and van Mechelen W, 1992). Additionally, research on the association between cigarette smoking and injuries has shown that individuals who smoke are at greater risk for musculoskeletal disabilities (Lincoln AE, Smith GS, Amoroso PJ, Bell NS, 2003). While individual risk factors for injuries have been explored, usually with exploratory (descriptive) studies, some risk factors may interact or be confounded by the presence of one or more factors.

The US Department of Labor (1999) found that workers in some occupations (truck drivers, non-construction laborers and nursing aides/orderlies) were at greater risk for nonfatal injury compared to workers in professional positions (US Department of Labor, 1999). The research to date clearly suggests that the relationship between occupational position (managerial versus laborer) and nonfatal work injuries is highly correlated to the relative exposure for an injury (Bonnie et al., 1999). For instance, employees in white-collar industries are not expected to experience high work injury rates because they are unlikely to be exposed to conditions where traumatic injuries occur. However, based on research findings, one might expect sheet metal workers to be at relatively greater risk for nonfatal injuries due to their exposures. In addition to occupational position, the US Department of Labor (1999) reported that conditions of work, such as the level of work activities (e.g., strenuous physical activity, bending, twisting, grasping, lifting, etc.) and contact with equipment (e.g., vibrating machinery) are closely related to lost work-time injuries.

Given that individuals may be predisposed to injuries due to fixed factors (i.e., genetics, gender and race) it is critical that prevention efforts target or intervene before an injury occurs or becomes disabling. Although it is well known that injuries are rarely the result of one particular risk factor, the safety and research communities implicitly recognize the role injury prevention and control policies have on decreasing injury rates among different populations. Furthermore, there are few studies that have closely examined the impact national policies have on injury prevention and control.

Prevalence of Injuries in the US Military and USAF

Paralleling that mortality from unintentional injury is a major problem within the U.S., unintentional injury is also the leading cause of death (excluding deaths due to warfare) for all military service personnel. In fact, unintentional injuries account for fatality rates ranging from 52 to 91 deaths per 1,000 person-years depending on the branch of service (Jones BH, Perrotta DM, Canham-Chervak ML, Nee MA, Brundage JF, 2000). These types of injuries also contribute to high rates of nonfatal morbidity, running the gamut from lost duty time to permanent disability (Helmkamp JC and Kennedy, RD, 1996; Songer TJ and LaPorte RE, 2000; and Smith GS, 2000). In 1999, nearly 26% of all hospitalizations and 60% of permanent disabilities among the active duty forces were caused by injuries (Armed Forces Epidemiology Board [AFEB], 1999). Ultimately, such injuries consume medical resources, and impair the capabilities of the military's operational mission readiness. While it has been established that most nonfatal injuries do not result in significant disability, little is known regarding the magnitude of unintentional nonfatal injury outcomes among the U.S. military forces.

Within the United States Air Force (USAF), unintentional nonfatal injuries were ranked as the third leading cause of hospitalizations, after digestive and pregnancy conditions (Smith GS, 2000). In 1994, 65% of all reported mishaps (i.e., injurious events) in the USAF resulted from industrial- and sports-related activities. The remaining 35% were attributed to motor vehicle crashes. Moreover, 31% of all hospitalizations were attributed to injuries from playing sports, or from falls, or jumps (Jones BH, et al, 2000). Despite current surveillance techniques, there is little extant literature that explicates the causal factors of nonfatal unintentional injuries within the Air Force active duty (ADAF) population.

Within recent refereed literature on military populations, several studies have explored the causal associations between risk factors for injury (such as self-reported health behaviors, frequency and type of exercise) and socio-demographic covariates and injury outcomes (Jones BH, Cowan DN, Tomlinson JP, Robinson FR, Polly DEW, Frykman PN, 1993; Krentz, MJ, Li G, Baker SP, 1997; Jones BH, Perrotta DM, Canham-Chervak ML, Nee MA, Brundage JF, 2000;

Kaufman KR, Brodine S, Shaffer R, 2000; Lauder TD, Baker SP, Smith GS, Lincoln AE, 2000; Popovich RM, Gardner JW, Potter R, Knapik JJ, Jones BH, 2000; Knapik JJ, Hauret KG, Arnold S, Canham-Chervak M, Mansfield AJ, Hoedebecke EL, McMillian D, 2003). Much of this research focused exclusively on U.S. military recruits and trainees in training environments such as Basic Combat/Military Training (BC/MT), AIT, cadets in the various military academies, officers in Officer Candidate/Training School (OCS or OTS), or in-residence professional military training for officers (e.g., Air War College, Army War College, etc.) (Ross J, 1993a; Ross J, 1993b; Wright DA, Knapik JJ, Bielenda CC, Zoltick JM, 1994 Bijur PE, Horodyski M, Egerton W, Kurzon M, Lifrak S, Friedman S, 1997; Pope RP, Herbert K, Kirwan JD, Graham BJ, 1999; Shaffer RA, Brodine SK, Ito SI, Le AT, 1999; Snedecor MR, Boudreau CF, Ellis BE, Schulman J, Hite M, Chambers B, 2000; Knapik JJ, Canham-Chervak M, Hauret K, Hoedebecke E, Laurin MJ, Cuthie J, 2001; Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, Jones BH, 2001; Knapik JJ, McCollam R, Canham-Chervak M, Hoedebecke E, Arnold S, Craig S, Barko W, 2002). However, very few injury studies have been conducted on the largest proportion of the active duty population in settings outside of such well-controlled environments: either on- or off-duty, or under more autonomous environmental conditions than that of recruits and trainees.

Extrinsic and Intrinsic Risk Factors Contributing to Unintentional Nonfatal Injuries

Distinguishing characteristics that are inherent to an individual from those of the external environment supplements the framework for studying unintentional nonfatal injuries. Examples of extrinsic factors that exert their own influence on injury outcomes within the USAF population ranges from geographical location to the meteorological conditions. Furthermore, the policies and methods for carrying out the mission of the USAF are incorporated into the hierarchical structure of the military and represent additional extrinsic factors influencing injuries. In contrast, intrinsic determinants are immutable or modifiable aspects of an individual such as, gender, age, height, weight, percentage of body fat, race/ethnicity, rank, level of education, marital status, aerobic capacity, tobacco use, co-morbidities, and history of previous injury. This study

addresses elements of the intrinsic and extrinsic risk factors that have been identified as contributing to nonfatal injury outcomes by research conducted previously.

Extrinsic Structural Factors Contributing to Injuries in USAF

USAF Major Commands: Function and Geography

At its most basic, the USAF is divided functionally and geographically into Major Commands (MAJCOM) and each Air Force Base (AFB) installation belongs to a MAJCOM based on a common wartime tasking. For example, Air Combat Command (ACC) is a functional MAJCOM that provides aircraft in support of Global Power and Global Reach; its primary wartime tasking. It is headquartered on Langley AFB, Virginia, and has AFB installations distributed across the United States with various fighter and attack aircraft (airframe or platform) assigned to each AFB. In contrast, Pacific Air Force Command and its AFB's are geographically located within the Pacific Rim, such as Japan, Hawaii, Alaska, Guam, and Korea. Its primary wartime functions encompass that of ACC's and for that matter, other MAJCOM's wartime functions, as it relates to carrying out those responsibilities within the Far East regions of the world.

These geographic and functional components are important to injury researchers because the functional aspects of the MAJCOM's correlate to the occupational requirements and therefore, may be used to identify those occupations at risk for certain types of injuries. Additionally, the geographic location of each installation may be used to explore the meteorological and environmental components influencing injuries incurred by USAF personnel. To illustrate this point, one would anticipate a higher rate of cold-weather injuries among personnel assigned to installations in Alaska and North Dakota, whereas hot weather injuries should be greatest among personnel assigned to bases in Texas and Arizona. In another example, most occupationally related parachuting injuries would be expected among pararescue personnel assigned to Air Force Special Operations Command, whereas injuries resulting from recreational skydiving could be observed in any active duty person participating in that activity.

USAF Policies to Prevent, Reduce and Control Injuries

The policies of the Department of Defense (DoD) place great emphasis on the safety and physical fitness of its personnel. Given that young, relatively healthy American adults (ages: 17+ years) provide the DoD with a population of uniformed armed forces, understanding the etiology and sequellae of unintentional nonfatal injuries is of paramount importance to injury prevention and control efforts. Therefore, it is imperative that USAF policy makers have up-to-date information regarding the natural history and risk factors for unintentional nonfatal injuries so that they may ensure adequate resources are available and appropriately used for targeted injury prevention and control within its population. This is often accomplished using the results from safety investigations. The purpose of the safety investigations within the USAF is "primarily to find causes of mishaps in order to take preventive actions" (Air Force Instruction [AFI]: 90-204, 2001, section 1.1.1.1.). Furthermore, the investigations serve to inform commanders on decision-making and actions to take "regarding their organizations safety, combat readiness, and mission accomplishment." (AFI: 90-204, 2001, section 1.1.1.1.).

Occupational Hazard Within the USAF

Few injury studies have been conducted on the largest proportion of the active duty population in settings outside of well-controlled environments (i.e., Basic Military Training [BMT], in-residence Professional Military Education [PME], etc.): either on- or off-duty, or under more autonomous environmental conditions than that of recruits and trainees (Jones BH, et al, 1993; Kragh Jr. JF, Taylor DC, 1995; Miser WF, Doukas WC, Lillegard WA, 1995; Kragh Jr. JF, Jones BH, Amoroso PJ, Heekin RD, 1996; Kragh Jr. JF, Taylor DC, 1996; Krentz, MJ, Li G, Baker SP, 1997; Robbins AS, et al, 2001; Smith TA, Cashman TM, 2002). In a recent descriptive epidemiological analysis produced by researchers at the Air Force Safety Center (2003), aircraft maintenance personnel sustained the largest number of lost workday injuries (n = 1289) during the study period (1993 – 2002), but security forces and operations personnel had the highest number of lost workdays per injury (7.5 and 7.6, respectively) (Copley BC, Burnham B, Shim M,

2003). However, no studies have documented how physical fitness requirements for the occupational specialties for active duty Air Force (ADAF) personnel relate to injury outcomes.

Intrinsic Factors Contributing to Injuries in USAF

Defining Cardiorespiratory Fitness

The measure of physiological and anatomic performance of maximal oxygen consumption, VO_{2max}, is the greatest rate at which the large muscle groups (e.g., quadriceps and hamstring muscles) can consume oxygen during exercise or physical activity (American College of Sports Medicine, 2000). According to the American College of Sports Medicine (ACSM), cardiorespiratory fitness (CR fitness), measured by VO_{2max} (expressed in units of ml/kg/min), is governed by proper functioning of the respiratory, cardiovascular, and musculoskeletal systems (Durstine LJ, 1993). Age is strongly associated with VO_{2max} and peaks somewhere between the age of 13 and 30 years (McArdle WD, Katch FI, Katch VL, 2001). With increasing age, VO_{2max} declines approximately 8% – 10% each decade after age 30, although this can be extremely variable among individuals who maintain physically active lifestyles (Walker JL, Murray TD, Jackson AS, Morrow JR Jr, Michaud TJ, 1999). Logically, it follows that a sedentary lifestyle contributes to the decline in cardiorespiratory function characterized by decreases in VO_{2max}, muscle mass and strength, flexibility, and an increase in body fat. Decreasing lean muscle mass and concomitant increases in body fat result in increases in cardiac output and heart rate, and a decrease in stroke volume (ACSM, 2000). It has been shown that women generally have 20% lower VO_{2max} compared to men of the same age (Woodson RD, 1984). In part, this is due to their relatively smaller cardiac and pulmonary systems and also, because men have 10% – 14% higher hemoglobin concentration than women (Woodson RD, 1984). However, VO_{2max} is related to body mass, and on average, women have approximately 25% body fat, whereas men average 15 percent. Adjusting for fat-free mass removes these gender differences (Jackson AS, Wier LT, Ayers GW, Beard EF, Stuteville JE, Blair SN, 1986). Additionally, genetics plays a large role in determining maximal aerobic capacity, and most exercise physiology researchers estimate that

25% – 40% of VO_{2max} is inherited (Bouchard C, Lesage R, Lortie G, Simoneau JA, Hamel P, Boulay MR, Perusse L, Theriault G, Leblanc C, 1986). The combination of immutable (i.e., hereditary, age and gender) and modifiable (i.e., lifestyle and health habits) profoundly influences VO_{2max} and must be taken into consideration while measuring a person's aerobic capacity.

Direct measures of cardiorespiratory capacity involve the use of gas analyzers that quantify expired gas fractions and ventilation during exercise and therefore, require specialized equipment and highly trained exercise physiologists to conduct individual assessments (ACSM, 2000). Consequently, the development of noninvasive measures such as treadmill test and cycle ergometry are more widely used by paraprofessional exercise trainers in evaluating the effectiveness of respiration by intracellular organelles, the mitochondria. Cycle ergometry is one type of submaximal fitness evaluations used to predict VO_{2max} and does not require extensive laboratory equipment or specially trained personnel to conduct the tests (McArdle WD, et al, 2001). Although VO_{2max} measured by cycle ergometry is not as costly in terms of resources, its accuracy is reduced by 10% - 15% with non-cyclists compared to treadmill tests (Brooks GA, Fahey TD, White TP, and Baldwin KM, 2000).

Physical Fitness, Tobacco Use, and Body Mass Index and USAF Policies

The mandate that Air Force active duty (ADAF) members must maintain standards for physical fitness, weight, and body fat is governed by one Air Force Policy Directive (AFPD) 40-5, *Fitness and Weight Management*, 1994 (AFPD 40-5, *Fitness and Weight Management*, 20 May 1994). Additionally, five subordinate Air Force Instructions (AFI) describes the administration of the various components of the AFPD, and its goals for healthy lifestyles are 1) AFI: 40-101, *Health Promotion Program* (1998); 2) AFI: 40-102, *Tobacco Use in the Air Force* (2002); 3) AFI: 40-501, *Air Force Fitness Program* (2002); 4) AFI: 40-502, *The Weight and Body Fat Management Program* (2002); and 5) AFI 40-104, *Nutrition Education*. Annually, ADAF servicemembers are required to undergo physical fitness and health assessments to determine their fitness for worldwide duty. All of these instructions expressly focus on optimizing cost . effective total force health and fitness among the USAF population. What is noteworthy is that

only the *Air Force Fitness Program* and *The Weight and Body Fat Management Program* instructions contain instructions on punitive measures commanders may take if the military member fails the fitness or weight and body fat evaluation. In those cases, the administrative options a commander must consider ranges from enrollment into programs designed to improve physical health to withholding or delaying promotion, and/or recommending separation from the Air Force (AFI: 40-501 and AFI: 40-502).

From 1 January 1992 until 31 December 2003, the USAF used cycle ergometry to assess aerobic capacity (i.e., cardiorespiratory fitness: submaximal VO_{2max}) in the active duty population (AFI: 40-501, 2002). The AFI clearly stated that physical fitness is the key to supporting the ever-changing requirements imposed by various Air Force missions, and describes annual aerobic fitness assessments of ADAF personnel (AFI: 40-501, 2002). The instruction endorsed the recommendations for physical activity outlined by the ACSM regarding mode or type of exercise (e.g., aerobic activity that uses the large muscle groups), intensity (e.g., 60%-90% of member's age-specific maximum heart rate estimate [220 – age]), duration (e.g., 20 – 60 minutes of continuous exercise) and frequency (e.g., a minimum of three days per week). It placed responsibility for maximizing physical performance on the individual servicemember, his/her unit commander, the Fitness Program Manager (FPM), and the "entire fitness team – member, Wing Commander or equivalent, unit commander, FPM, medical, and Services personnel" (AFI: 40-501, 2002, Section 1.2).

Body mass index (BMI) is an anthropometric estimate of body fat and is a function of body weight relative to height, expressed in kg per meter squared (kg/m^2) (Durstine, LJ). The Centers for Disease Control and Prevention (CDC) adopted standardized categories for weight status based on BMI values which were, in turn, based upon the clinical guidelines established by the National Heart, Lung, and Blood Institute (CDC website, 2004). Using those categories, obese individuals are defined as having a BMI greater than or equal to 30 kg/m^2 while people classified as having normal or "desirable" weight have a BMI between 20 kg/m^2 and 24.9 kg/m^2 (CDC website, 2004). The Air Force established its own maximum body fat standards (assessed using a Gulick® tape measure) without using the CDC's BMI categories (AFI: 40-502, 2002). It

permits men and women younger than age 29 years to have a maximum proportion of body fat of 20% and 28%, respectively, whereas men and women older than age 30 years are allowed a maximum body fat percentage of 24% and 32%, respectively (AFI: 40-502, 2002). Air Force policy makers understand that maintaining optimal body weight/fat includes providing education on proper nutrition, but this characteristic of physical health is only cursorily addressed within *Health Promotion* instruction, AFI: 40-101. While the emphasis on ideal body weight and percentage of body fat is implicitly stated in USAF policies, specific instructions on how active duty members are to attain and maintain the USAF standard are vague or completely lacking.

Rounding out the intrinsic factors of physical health defined by the USAF and its policies that address them, the use of all types of tobacco products by all servicemembers is discouraged (AFI: 40-102, 2002). The Air Force adopted the CDC's definition for tobacco products, defined as "loose tobacco used by "dippers" and "chewers") and all types of smoking tobacco, to include cigars" (AFI: 40-102, 2002, section 1.1.1.). Tobacco use is strictly prohibited in the workplace, most indoor facilities, and by USAF students in any formal training (i.e., Professional Military Training [PME], Basic Military Training [BMT], etc.) during school hours (AFI: 40-102, 2002). As part of tobacco use prevention and control policy (2002), health care providers (medical and dental) are required to ask about tobacco use at every encounter, and Unit Fitness Program Manager's query the individual prior to administering the CR fitness evaluation. Additionally, tobacco users are offered medical advice and education materials about the risks of tobacco use, and referral to tobacco cessation classes and nicotine replacement therapies, if requested.

Defining Unintentional Nonfatal Injury

Most injury studies implicitly define unintentional nonfatal injury to include "any unintentional damage to the body resulting from acute exposure to thermal, mechanical, electrical, radiant or chemical energy, or from the absence of such essentials as heat or oxygen" (DoD Injury Surveillance and Prevention Work Group, 1999, page C-8). On the other hand, overuse injuries are defined as: "tissue damage resulting from repetitive, cumulative microtrauma (e.g., tendonitis, stress fractures, patellofemoral syndrome)" (DoD Injury Surveillance and

Prevention Work Group, 1999, page 6-7). While several studies have explored the relationships of incident unintentional nonfatal injuries, many researchers include overuse injuries and acute injuries in their definition (Jones, 1983; Conway and Cronan, 1992; Jones, et al, 1993; Knapik J, Ang P, Reynolds K, Jones BJ, 1993; Ross J, 1993a-b; Jones, et al, 1994; Jordaan G and Schwellnus MP, 1994; Stofan JR, DiPietro L, Davis D, Kowl HW, Blair SN, 1998; Baldry Currens JA, Coats TJ, 2000; Schneider GA, Bigelow C, Amoroso PJ, 2000; Potter RN, Gardner JW, Deuster PA, Jenkins P, McKee K Jr, Jones BH, 2002; Lincoln AE, Smith GS, Amoroso PJ, Bell NS, 2003; and Knapik JJ, Hauret KG, Lange JL, Jovag B, 2003). However, nonfatal injuries resulting from repetitive trauma differ from those caused by a sudden-onset, or the acute transfer of energy resulting in an abrupt tissue overload, thereby damaging musculoskeletal or connective tissues (Ross J, 1993a-b; Jones BH, et al 1994; Knapik JJ, et al, 2003a-c). Therefore, it is important to distinguish between injuries that are the end-result of cumulative trauma versus those that are the product of acute trauma. This is especially true since certain risk factors, such as age, gender and lifestyle behaviors (e.g., tobacco use, nutritional status, weight, and height) are differentially associated with acute injuries versus injuries resulting from chronic conditions (Jones BH, 1983; Conway and Cronan, 1992; Jones, et al; 1993; Knapik J, et al, 1993; Ross J, 1993a-b; Reynolds KH, Heckel A, Witt CE, Martin JW, Pollard JA, Knapik JJ, Jones BH, 1994; Bonnie RG, et al, 1999; Bell NS, Mangione TW, Hemenway D, Amoroso PJ, Jones BH, 2000; Sulsky SI, Mundt KA, Bigelow C, Amoroso PJ, 2000; Hootman JM, Macera CA, Ainsworth BE, Martin M, Addy CL, Blair SN, 2001; and Sharp MA, Patton JF, Knapik JJ, Hauret K, Mello RP, Ito M, Frykman PN, 2002).

ICD-9-CM, STANAG, and Trauma Diagnostic Codes

The International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) or its replacement, the ICD-10, is the most commonly used system for classifying morbidity and mortality information. It is frequently used for statistical purposes, as well as indexing medical discharge data by disease, condition, treatment, and for data storage and retrieval (International Classification of Diseases, 9th Revision, Clinical Modification, 1986). Such coding provides the

basis for most epidemiological studies of injuries within the civilian sector resulting in inpatient or ambulatory medical visits. In contrast, the North Atlantic Treaty Organization STANdardization AGreement (STANAG) codes characterizing external causes of injuries for all Department of Defense hospitalizations is an injury coding system unique to the military. It is divided into two codes, a trauma code (intent category such as, intentional, unintentional, etc.), and the injury code, which is similar to the ICD-9-CM scheme's E code for external cause (i.e., falls, sports, poisoning, etc.). However, ICD-9-CM and the STANAG diagnostic codes are utilized separately or together in studying injuries throughout the military and provide the foundation of the study described within this document.

Study Rationale and Implications

Despite the depth of military research on the relationship of physical fitness risk factors and unintentional nonfatal injuries, the inability to control for potential confounding (i.e., psychosocial and cultural health practices, economic and political influences, level of education, and injury severity) limits our knowledge of the contribution of cardiorespiratory fitness to injuries in military populations. Additionally, USAF researchers are hampered by a variety of difficulties, including accurate exposure assessment, defining inclusion and exclusion criteria (i.e., chronic vs. acute injuries), the need for large numbers of study participants, length of time needed to detect types of injuries, and the costs associated with such investigations (i.e., the human and materiel sources). Data on a number of risk factors associated with unintentional nonfatal injuries may resolve a number of the problems encountered in previous studies by combining existing military administrative databases. For example, the USAF safety community utilizes a relational database (Air Force Safety Automated System, AFSAS) that enables investigators to examine longitudinal data regarding reported injury events, termed "mishaps," whose injury severity ranges from loss of duty time to death (Copley, BC, Lt Col, telephone interview, July 2003).

The intrinsic and extrinsic risk factors described above have been found to detrimentally affect military operations in peacetime, and during peacekeeping and wartime operations. Given the anatomic and physiological systems function in concert to distribute oxygen throughout the

body, surrogate measures of cardiorespiratory fitness include body weight (kg) and height (m), or body mass index (BMI, expressed in kg/m^2), in addition to age, gender and tobacco use. Researchers have found that as BMI increases, morbidity and mortality from cardiovascular diseases and injuries also increase (Conway and Cronan, 1992; Henderson NE, Knapik JJ, Shaffer SW, McKenzie TH, Schneider GM, 2000; and Reynolds K, Cosio-Lima L, Creedon J, Gregg R, Zigmont T, 2002). These surrogate measures of cardiorespiratory fitness could be used as predictors of unintentional nonfatal injuries. In addition, several studies have demonstrated the biomechanical influences of body mass, physical ability and activity on injuries of the musculoskeletal system. Although many studies describe patterns of injuries in active duty populations among all branches of the service, none focus exclusively on the relationship of cardiorespiratory risk factors to unintentional nonfatal injury-related morbidity sustained by active duty Air Force personnel.

Given the variety and specificity of injury definitions found throughout research literature, unintentional nonfatal injury in this dissertation combines acute and repetitive trauma injuries under the umbrella of "injury" using primarily ICD-9-CM codes. Where it is relevant in answering specific research questions, distinguishing between acute versus chronic injuries will be made clear.

It is hypothesized that the physiological and biomechanical mechanisms of cardiorespiratory fitness (primarily, submaximal VO_{2max} and BMI) are associated with an increased risk for unintentional nonfatal injuries among ADAF personnel. Therefore, the outcome of such influences could be detected with a study of active duty Air Force personnel using an exploratory (univariate and bivariate analyses) and explanatory (retrospective case-control) design while controlling for potential confounders discussed in this document. The results from this study may be used to inform the decisions of USAF and DoD policy makers regarding efforts to prevent or control injury among active duty Air Force personnel.

The research presented herein seeks to fill an important gap in knowledge regarding the relationship between levels of cardiorespiratory (CR) fitness and injuries among ADAF personnel. The descriptive analysis provides a comprehensive assessment of injuries relative to CR fitness

levels, and supplements the explanatory element of this study. The explanatory portion of the study examines the probability that an active duty personnel experience different types of injuries given differential CR fitness levels. No other studies in the refereed literature have fully explicated how, if at all, CR fitness levels predict types of unintentional nonfatal injuries or anatomic location of the injury among military populations. Finally, the study assesses opportunities for proposing prevention-specific policies to reduce the probability of unintentional injury-related morbidity among ADAF personnel.

CHAPTER 2. CONCEPTUAL FRAMEWORK AND REVIEW OF RELEVANT RESEARCH

Overview

This chapter reviews selected literature pertaining to the intrinsic and extrinsic cardiorespiratory fitness risk factors for unintentional nonfatal injuries that were presented in Chapter One. First, research related to the primary risk factors and their association with unintentional nonfatal injuries is described. Second, research regarding secondary risk factors related to unintentional nonfatal injuries is discussed. Third, literature concerning the types of unintentional nonfatal injuries is discussed. Finally, the chapter concludes with a description for the basis for the conceptual model and framework used in this study of the relationship between cardiorespiratory fitness and nonfatal injuries among active duty Air Force personnel.

Primary Risk Factors of Interest

Submaximal VO_{2max}

Previous studies have not examined how the combination of various physical risk factors, such as physical activity, VO_{2max}, maximal allowable body fat, and tobacco use may influence nonfatal injuries among military populations when performing day-to-day operations. However, the relationship between cardiorespiratory (CR) fitness and nonfatal injury has been studied in military recruits and trainees undergoing indoctrination and advanced training programs (e.g., Basic Military Training [BMT], Basic Combat Training [BCT], etc.). In fact, most military-specific research has used U.S. Army personnel in studies wherein certain risk factors for injuries were identified, including decreased physical activity, poor aerobic fitness, increased running frequency and the distances run, cigarette smoking, and obesity (Jones BH, 1983; Conway TL, Cronan TA, 1992; Jones BH, Cowan DN, Tomlinson JP, Robinson FR, Polly DEW, 1993; Amoroso PJ, Bell

NS, Jones BH, 1997; Jones BH, et al, 2000; Altarac M, Gardner JW, Popovich RM, Potter R, Knapik JJ, Jones BH, 2000; and Friedl KE and Leu JR, 2002). Many of these same risk factors have been validated in studies of unintentional nonfatal injuries among civilian populations (Durstine LJ, 1993; Blair SN, Kampert JB, Kohl HW 3rd, Barlow CE, Macera CA, Paffenbarger RS Jr, Gibbons LW, 1996; Stofan JR, DiPietro L, Davis D, Kowl HW, Blair SN, 1998; and Hootman JM, Macera CA, Ainsworth BE, Martin M, Addy CL, Blair SN, 2001).

Robbins et al, explored risk factors for cycle ergometry fitness evaluation failures among ADAF personnel gathered from self-reported health risk assessment data using a retrospective cohort study design (Robbins AS, Chao SY, Fonseca VP, Snedecor MS, Knapik JJ, 2001). They found that men and women who were overweight or obese were more likely to fail the cycle ergometry fitness evaluation if they had failed the same type of fitness test in the preceding year. Furthermore, their results showed that an adverse effect on cycle ergometry pass rates was observed among men and women with low exercise frequency (less than once a week) and among men who smoked cigarettes. The study described passing scores for aerobic fitness, a measure of cardiorespiratory physical fitness, to be approximately 80% for males in the entire USAF cohort (1999), and nearly 86% among USAF females (Robbins et al., 2001). Robbins and his colleagues also found that approximately 61% of males and 27% of females met the USAF definition for overweight or obesity (BMI $\geq$30kg/m^2) (Robbins et al., 2001). Self-reported tobacco use (any versus none) was nearly 23% for both men and women (Robbins et al., 2001). However, their study made no mention of whether cardiorespiratory fitness contributes to increased risk for any deleterious health condition, or whether tobacco use and exercise frequency are associated with cycle ergometry scores.

While investigating the influence of age and physical training on cardiorespiratory fitness measures, Knapik and colleagues' results showed that "tasks involving different physiological systems may be influenced differentially by age and training" (Knapik JJ, Banderet LE, Vogel JA, Bahrke MS, O'Connor JS, 1996, p.490). In a separate study of military recruits, the risk for discharge was highest among those with lower performance on the physical fitness test during training (Knapik JJ, Canham-Chervak M, Hauret K, Hoedebecke E, Laurin MJ, Cuthie J, 2001).

In their review, Deuster et al. argued that many studies point to cardiorespiratory fitness as the one component that is inversely related to injury (i.e., the higher the level of cardiorespiratory fitness, the less likely an injury will occur) (Deuster PA, Jones BH, Moore J, 1997). In yet another study, Knapik et al. found that the incidence of injury was higher in younger infantry soldiers and among those with lower levels of physical fitness (Knapik J, Ang P, Reynolds K, Jones BJ, 1993). Clearly, cardiorespiratory fitness plays a role in injury outcomes, and among military personnel who have a lower aerobic capacity upon entry into indoctrination training the risk for injury is highest.

Body Mass Index

Researchers have found that as BMI increases, morbidity and mortality from cardiovascular diseases and injuries increase (Conway TL, Cronan TA, 1992; Henderson NE, Knapik JJ, Shaffer SW, McKenzie TH, Schneider GM, 2000; Reynolds K, Cosio-Lima L, Creedon J, Gregg R, Zigmont T, 2002). Furthermore, several studies in both civilian and military populations have demonstrated that the biomechanical forces resulting in low-back and knee injuries are related to an individual's body mass index, physical ability and activity (Macera, CA., Jackson KL, Hagenmaier GW, Kronenfeld JJ, Kohl HW, Blair SN, 1989; Pope MH, 1989; Burdorf A, Naaktgeboren B, de Groot HC, 1993; Myers AH, Baker SP, Li G, Smith GS, Wiker S, Liang KY, Johnson JV, 1999; Lincoln AE, Smith GS, Amoroso PJ, Bell NS, 2003; Billings CE, 2004; Bejia I, Younes M, Jamila HB, Khalfallah T, Ben Salem K, Touzi M, Akrout M, Bergaoui N, 2005). Jones suggested that higher rates of lower extremity injuries among female recruits during Basic Military Training (BMT) were directly related to poorer physical condition and higher percentage of fat free mass at entry into military service when compared to their male counterparts (Jones BH, 1983). In another study, age and increased body mass were independent risk factors for injuries among female soldiers in Combat Medic Advanced Individual Training (AIT) (Henderson et al., 2000). Billings found that overweight or obese cadets were more likely to sustain an injury during Basic Cadet Training at the United States Air Force Academy (USAFA) (Billings CE, 2004). While many studies have produced equivocal results regarding the influence of BMI on injuries, very

high or very low BMI is related to higher risk for injury among adults (Macera et al., 1989; Jones et al., 1993; Heir T and Eide G, 1997).

Physical Activity

In 1995, the Centers for Disease Control and Prevention (CDC) and the American College of Sports Medicine (ACSM) issued physical activity recommendations for all adults. In that statement, adults were urged to participate in vigorous fitness activities for at least 30 minutes each day (CDC, 1995; Pate RR, Pratt M, Blair SN, Haskell WL, Macera CA, Bouchard C, Buchner D, Ettinger W, Heath GW, King AC, et al., 1995; ACSM, 1996). Numerous military-specific studies have demonstrated that a dose-response relationship exists whereby increases in physical activity were associated with concomitant increased risk for injury, especially injuries to the lower extremities (Jones BH, 1983). Billings found that intercollegiate athletes (i.e., those who had higher levels of physical activity) were at greater risk for injury during indoctrination training at USAFA (Billings CE, 2004). Overuse injuries (e.g., stress fractures, etc.) are often cited as a direct result of increased running frequency and longer distances traveled (Jones BH, 1983; Jordaan and Schwellnus, 1994; Jones BH, Thacker SB, Gilchrist J, Kimsey CD Jr, Sosin DM, 2004). Among men entering active duty, a history of low physical activity was associated with a greater risk for injuries (Knapik et al., 2000). In a separate study of civilians, Hootman et al. showed that increased duration of physical activity resulted in increased musculoskeletal injuries among men and women (Hootman JM, Macera CA, Ainsworth BE, Martin M, Addy CL, Blair SN, 2001).

Tobacco Use

It is clear that tobacco use is a causal factor for many diseases (i.e., cancer, cardiovascular conditions, etc.), and it is believed to be a risk factor for injuries (Powell KE, Thompson PD, Caspersen CJ, Kendrick JS, 1987; Blake GH and Parker JA, 1991; Conway and Cronan, 1992; Reynolds KL, Heckel HA, Witt CE, Martin JW, Pollard JA, Knapik JJ, Jones BH, 1994; Altarac M, et al, 2000; Henderson et al., 2000; Robbins AS, Chao SY, Fonseca VP, Snedecor MS, Knapik

JJ, 2001; Lincoln et al., 2003). In 2002, Lincoln and his colleagues attempted to determine the association of cigarette smoking with the development of a physical disability after an initial hospitalization among US Army personnel using a retrospective cohort design (Lincoln et al., 2003). They found statistically significant correlations between increased smoking levels (i.e., light to moderate and heavy smokers) and long-term disability for injuries to the knee, rotator cuff, or intervertebral disc displacement (Lincoln et al., 2003). While this study has merit in its design and analyses, the authors did not adjust for body composition (i.e., weight and height, percent body fat or body mass index), physical ability or physical activity: physical fitness scores, or exercise frequency, type, intensity, and duration. In a separate study of soldiers on a 100-mile road march, the risk of blisters was higher among those who smoked cigarettes compared to the nonsmokers (Risk Ratio = 1.8) (Reynolds KL, White JS, Knapik JJ, Witt CE, Amoroso PJ, 1999). Among soldiers in their first year of infantry training, Reynolds et al., found that soldiers who smoked had a higher likelihood for lower extremity and low back musculoskeletal injuries compared to nonsmokers (OR = 3.0; 95% CI = 1.5 – 6.1) (Reynolds et al., 1994). In another study, an increased risk for injuries was found among soldiers with a history of smoking more than 10 cigarettes a day (Relative Risk [RR] = 1.8; 95% CI = 1.2, 2.8) (Jones BH, Cowan DN, Tomlinson JP, Robinson JR, Polly DW, Frykman PN, 1993).

Secondary Risk Factors of Interest

Socio-demographic factors (e.g., age, gender, ethnicity/race, etc.)

Military injury researchers have also explored the roles of age, gender, and race in influencing cardiorespiratory fitness and injuries among the military. Bell and her colleagues (2000) found that women were twice as likely as men to experience injuries after controlling for potential confounders (Bell NS, Mangione TW, Hemenway D, Amoroso PJ, Jones BH, 2000). In a separate study of U.S. Army Combat Medics, age and higher body mass were independent risk factors for injuries among women but not men (Henderson et al., 2000). Among male and female officer candidates at West Point, women had injury rates 2.5 times that of men and were

hospitalized 3.9 times more often (Bijur PE, Horodyski M, Egerton W, Kurzon M, Lifrak S, Friedman S, 1997). In a study of Army parachutists, Amoroso et al., found that women were twice as likely as men to sustain a lower extremity injury (Odds Ratio [OR] = 2.03; 95% Confidence Interval [CI] = 1.39 – 2.99, $p < 0.0005$) (Amoroso PH, Bell NS, Jones BH, 1997). Their study also showed that injury severity (i.e., fractures) was higher among female parachutists than their male counterparts (OR = 2.03; 95% CI = 1.37 – 3.03, $p < 0.0005$) (Amoroso et al., 1997).

It is believed that greater bone mineral density among blacks compared to whites partially explains the influence of race on musculoskeletal injuries, particularly fractures (Henry YM, Eastell R, 2000; Nelson DA, Jacobsen G, Barondess DA, Parfitt AM, 1995; Finkelstein JS, Lee ML, Sowers M, Ettinger B, Neer RM, Kelsey JL, Cauley JA, Huang MH, Greendale GA, 2002). In a prospective controlled trial examining the use of shock absorbing insoles to prevent lower extremity stress fractures, Gardner and his co-authors found higher rates for stress fractures among white U.S. Marine recruits compared to black recruits, while controlling for other covariates (Gardner LI Jr, Dziados JE, Jones BH, Brundage JF, Harris JM, Sullivan R, Gill P, 1988). While this experimental design did demonstrate increased risk for such injuries, other studies have shown that blacks have greater bone mineral density than do whites, and this difference alone could account for the study's findings (Nelson DA, Jacobsen G, Barondess DA, Parfitt AM, 1995; Finkelstein JS, Lee ML, Sowers M, Ettinger B, Neer RM, Kelsey JL, Cauley JA, Huang MH, Greendale GA, 2002).

Occupation and Rank

The inverse relationship between increasing status or rank and decreasing risk for injury among military and civilian populations has been examined from occupational perspectives. Helmkamp and Bone (1986) demonstrated that the most junior enlisted personnel (i.e., E1) experienced more injuries than senior enlisted (i.e., E2 – E9) (Helmkamp JC, Bone CM, 1986). Smith and Cashman found that junior enlisted (E1 – E5) sustained twice the number of injuries as senior enlisted and officers (E6 – O6). Other studies have demonstrated that individuals

assigned to particular occupational categories (e.g., combat versus support) are at increased risk for injuries. However, studies of military trainee populations refute these findings where older recruits bear the greater burden of injuries than their younger counterparts during training (Jones et al. 1993; Heir T, 1998; Henderson et al., 2000). One suggestion for these findings is that senior enlisted and officers occupy supervisory or managerial positions that minimize their exposure to physically hazardous activities. Another rationale that may explain findings where older military trainees have higher rates of injuries is the emphasis on physical fitness and they may have decreased resilience to the physical demands of the training environment.

Types of Injuries

Many studies have addressed acute musculoskeletal injuries (e.g., sprains, fractures, etc.) among military populations and its association with sports and recreational activities, physical fitness training, and occupation (Jones BH, 1983; Jones BH, Cowan DN, Knapik JJ, 1994; Kaufman KR, Brodine S, Shaffer R, 2000; Lauder TD, Baker SP, Smith GS, Lincoln AE, 2000; Knapik JJ, Canham-Chervak M, Hauret K, Hoedebecke E, Laurin MJ, Cuthie J, 2001; Jones BH, Thacker SB, Gilchrist J, Kimsey CD Jr, Sosin DM, 2002; Knapik JJ, Hauret KG, Arnold S, Canham-Chervak M, Mansfield AJ, Hoedebecke EL, McMillian D, 2003). For example, musculoskeletal injuries to the lower extremity (i.e., ankle sprains) comprised the majority of injuries to U.S. Army Rangers involved in Operation Just Cause (Miser WF, Lillegard WA, Doukas WC, 1995). This is in consonance with studies of civilians where participating in routine physical fitness activities resulted in lower extremity injuries were most common (Hootman JM, Macera CA, Ainsworth BE, Martin M, Addy CL, Blair SN, 2001). It is also well documented that chronic injuries such as low back pain and repetitive trauma disorders among the US military and civilian populations are a function of physical and psychological risk factors (Garg A, Moore JS, 1992; Burdorf A, Naaktgeboren B, de Groot HC, 1993; Myers AH, Baker SP, Li G, Smith GS, Wiker S, Liang KY, Johnson JV, 1999; Bejia I, Younes M, Jamila HB, Khalfallah T, Ben Salem K, Touzi M, Akrout M, Bergaoui N, 2005).

Theoretical Model – Haddon's Matrix and its applicability

The theoretical mechanisms that relate cardiorespiratory fitness risk factors with a subsequent unintentional nonfatal injury are represented in Figures 2.1 – 2.3. In broad terms, the primary mechanisms are based upon the individual influences of individual cardiorespiratory and occupational risk factors on injury outcomes, and interactions between the risk factors. These mechanisms represent the complexities of the associations and control for confounders that have limited earlier epidemiological investigations of cardiorespiratory fitness and unintentional nonfatal injuries in military populations. Furthermore, the specific indicators represent the components that have been associated with such injuries with respect to differential levels of cardiorespiratory fitness, BMI, tobacco use, and physical activity (Henderson et al., 2000; Robbins AS, Chao SY, Fonseca VP, Snedecor MS and Knapik JJ, 2001; Knapik JJ, Canham-Chervak M, Hauret K, Hoedebecke E, Laurin MJ, and Cuthie J, 2001; Knapik JJ, Sharp MA, Canham-Chervak M, Hauret K, Patton JF, and Jones BH, 2001; Lincoln AE, Smith GS, Amoroso PJ, and Bell NS, 2003).

Several studies have explored numerous relationships between risk factors and injuries in military populations. In August 1999, the DoD Armed Forces Epidemiology Board (AFEB) Injury Surveillance and Prevention Work Group (ISPWG) produced the *Atlas of Injuries in the U.S. Armed Forces*. It was the first document of its kind to compile data collected on the military between 1980 and 1994, and explicitly described the significance of the problem of injuries for the separate branches of services (AFEB, 1999). While the AFEB work group enumerated the extent to which all injuries are the leading cause of morbidity and mortality in the military, its report lacked an adequate description of unintentional nonfatal injury etiology. Injury risk factors could be examined using a conceptual framework that permits mathematically operationalizing certain independent predictors for injuries among active duty USAF personnel.

The modified Haddon Matrix provides a conceptual framework (Figure 2.1) whereby pre-injury, injury and post-injury events intersect with the human factors, agent and physical and social environments. Using the conceptual model (Figure 2.2) derived from Haddon's matrix and merging data from existing DoD databases facilitates quantifying measurable risk factors that

may be associated with injuries in active duty USAF airmen. While many variables in the modified Haddon matrix cannot be measured with existing data sources; however, operationalizing the cardiorespiratory and occupational risk factors might be accomplished using the conceptual model outlined in Figure 2.2 (Haddon W, 1972).

This model is intended to incorporate several plausible variables of individual and occupational factors and unintentional nonfatal injury outcomes presented earlier. It is further suggested that the variables selected are considered to affect the more complex causal pathways depicted in Figure 2.3. Although linking existing military administrative databases provides this study with many variables of interest, it is impossible to capture the influences of all variables identified in both the modified Haddon matrix (Figure 2.1) or the overarching conceptual framework put forth in Figure 2.3. Therefore, the model in Figure 2.2 will be the basis for the study. Additionally, areas ripe for research will be identified where existing literature has not explicated the relationship between cardiorespiratory fitness and unintentional nonfatal injuries.

Figure 2.1. Conceptual Model Using the Haddon Phase-Factor Matrix

EVENT	HUMAN FACTORS	AGENT	PHYSICAL AND SOCIAL ENVIRONMENT
PRE-INJURY	Age; gender; height; weight; VO_{2max}; marital status; race/ethnicity; rank; time in grade; length of service; level of education; type & frequency of exercise; time, intensity & duration of exercise; physical ability; anatomic & physiological co-morbidities; nutritional status; fatigue; psychosocial & cultural knowledge, attitude, & skills regarding physical fitness, health, occupational safety, and injury prevention & control; knowledge & use of PPE; medications; tobacco & alcohol use; prescription & illicit drugs; adherence to USAF fitness & health policies	Event activity; clothing; footwear; ± fitness & occupational equipment; availability of proper PPE; types of safety devices; nature of injury (e.g., slip, trip, fall, struck by, etc.)	Economic and political policies governing accessions, physical fitness, individual health, occupational safety and health; injury prevention and control; meteorological conditions; geographic location of AFB; time of day/week; assigned Major Command; occupation (AFSC)
INJURY	Age; gender; height; weight; anatomic location; general health – physiological, physical, psychological condition, and pre-existing co-morbidities; use of PPE; adherence to safety recommendations; tobacco use; prescription & illicit drugs use; and alcohol use	Event activity; clothing; footwear; ± fitness & occupational equipment; integrity of PPE; type of safety devices; type & severity of injury	Enforcement of injury prevention and control policies; adherence to policies/laws; physical design of and geographic location where injury occurs; presence of hazards; meteorological conditions; conditions of light
POST-INJURY	Age; gender; same as "human factors pre-injury" characteristics; communication abilities	Type and severity of injury; types of safety devices; ± integrity of safety equipment; injury outcome	Time of day/week; meteorological conditions; proximity to EMS/MTF; response by EMS; police/EMS logistics & delivery system; control of bystanders/other victims; quality of medical care & rehabilitation services

Adapted from Haddon w Jr., 1972.

Figure 2.2. Relationships Between *Measurable* Risk Factors and Injury-related Morbidity

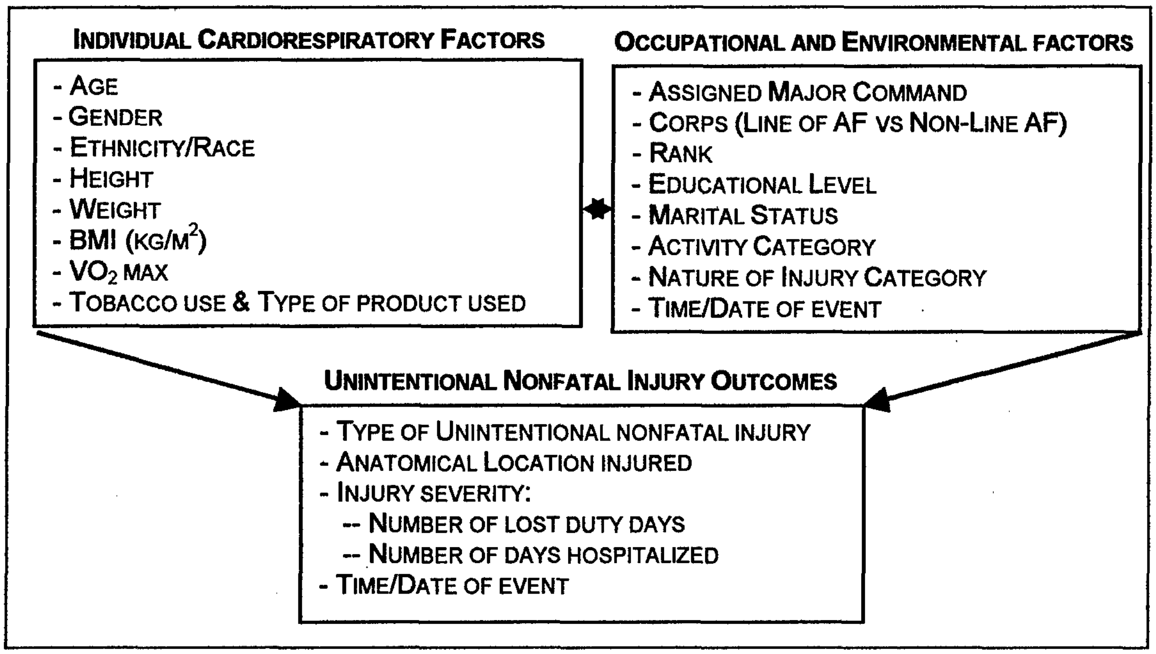
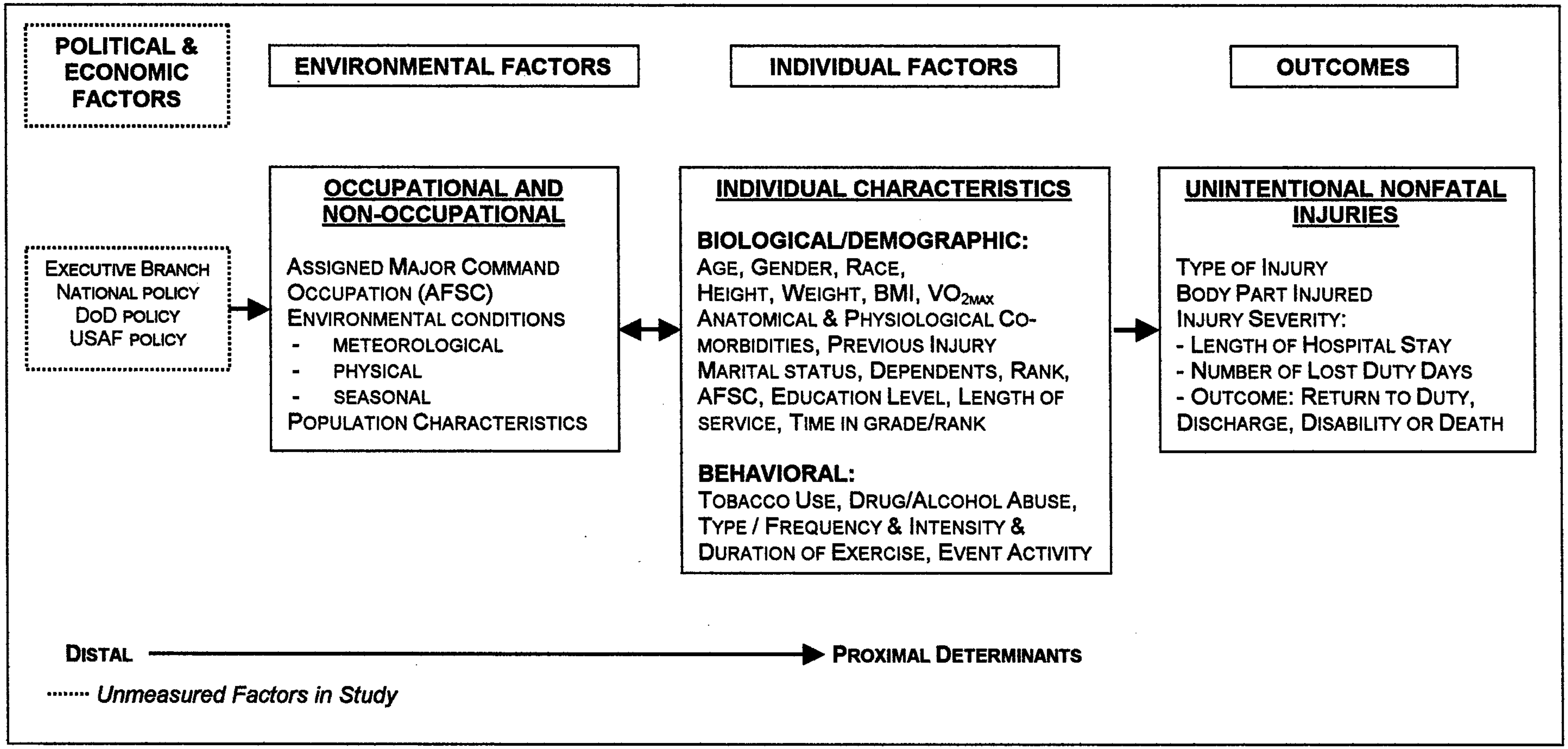


Figure 2.3. Conceptual Model: Relationships Between Risk Factors and Unintentional Injury-related Morbidity



CHAPTER 3. METHODS

Specific Aims, Hypotheses and Research Questions

The overarching goal of this study was to quantify the association between indicators of CR fitness and injury-related morbidity among the active duty Air Force population. Therefore, this study sought to describe injury severity and types of injury relative to CR fitness levels among ADAF personnel, and whether differential exposures (e.g., high versus low CR fitness) resulted in differential injury outcomes (i.e., more or less lost duty time). Indicators of CR fitness included individual biological, socio-demographic and behavioral characteristics, such as age, gender, ethnicity, and level of education, marital status, rank, weight, height, BMI, submaximal VO_2 scores, and self-reported tobacco use. Outcomes of interest were specific diagnoses of unintentional nonfatal injuries, anatomic location injured, number of lost duty days and the number of days hospitalized. Additionally, risk factors for event activity (e.g., sports and recreation) were investigated.

The specific aims of this study were to:

1. Describe unintentional injury-related morbidity among ADAF personnel in 2000.
2. Describe CR physical fitness levels (BMI and submaximal VO_2) among ADAF personnel in 1999 and 2000.
3. Evaluate the relationships between CR fitness risk factors (e.g., measured by submaximal VO_2, and BMI) and unintentional injury-related morbidity.
    a. Ascertain whether differential levels of CR risk factors (high versus low CR fitness and BMI) were associated with nonfatal injury outcome (i.e., anatomic location and type of injury).
    b. Characterize the probability of unintentional injury-related morbidity by activity (i.e., sports and recreation).

4. Assess opportunities for prevention (primary, secondary or tertiary) measures for risk factors found to be associated with unintentional nonfatal injuries.

5. Where opportunities are discovered, propose prevention-specific policies for the organizational and medical management of conditions that reduce the probability of unintentional injury-related morbidity among ADAF personnel.

Hypothesis

The tested hypotheses pertain to the third specific aim. The choice of variables used to test these hypotheses was based on results found throughout the empirical literature on injuries among military personnel.

Hypothesis: Low CR fitness levels measured by low submaximal VO_2 (i.e., below the age- and gender-specific minimum passing scores defined by AFI 40-501, 2002, Table 3.1), and high BMI ($\geq$30 kg/m^2) are associated with increased risk for unintentional injury-related morbidity among ADAF personnel.

1. **Sub-hypothesis #1:** High CR fitness levels (measured by passing submaximal VO_2 scores at or above the age- and gender-specific category found in Table 3.1 and a BMI <25 kg/m^2) are associated with increased risk for injuries resulting from sports and recreational activities (e.g., basketball, softball, snowboarding, etc.).

2. **Sub-hypothesis #2:** Low CR fitness levels (measured by failing submaximal VO_2 scores below the age- and gender-specific category found in Table 3.1 and a BMI $\geq$30 kg/m^2) are associated with increased risk for "lumbago/backache" injuries (i.e., ICD-9-CM codes 724.2 and 724.5).

3. **Sub-hypothesis #3:** CR fitness levels are not associated with increased risk for noise-induced hearing loss.

Table 3.1. USAF Minimum Passing Values for Submaximal VO_2 by Age & Gender

Age Group (in yrs)	Submaximal VO_2 (ml/kg/min)	
	Males	Females
≤ 24	35	27
25-29	34	27
30-34	32	27
35-39	31	26
40-44	30	26
45-49	29	25
50-54	28	24
≥ 55	27	22

SOURCE: Air Force Instruction 40-501, The Air Force Fitness Program, April 2002, pp. 22-23

Research Questions

This study sought to answer five specific research questions:

Research Question 1 What is the distribution of cycle ergometry fitness measurements in cases and controls stratified by age, gender, race, level of education, rank, marital status, and corps?

Research Question 2 What is the distribution of BMI (NIH categories: underweight, normal weight, overweight and obese) among study participants for the study period stratified by age, gender, ethnicity, level of education, rank, marital status, and corps?

Research Question 3 What is the relationship unintentional nonfatal injury to CR fitness among ADAF personnel?

Research Question 4 What is the relationship "sports and recreational" injuries to CR fitness among ADAF personnel?

Research Question 5 Is there an increased CR risk (low submaximal VO_2 and high BMI) for injury to a specific anatomic location (e.g., knee, wrist/hand/fingers, etc.)?

Research Question 6 Is there an increased CR risk (low submaximal VO_2 and high BMI) for specific types of injury (e.g., fracture, sprain, etc.)?

Methods

Purpose

The purpose of this study was to examine the association of cardiorespiratory fitness with unintentional non-fatal injury among Air Force personnel.

Design

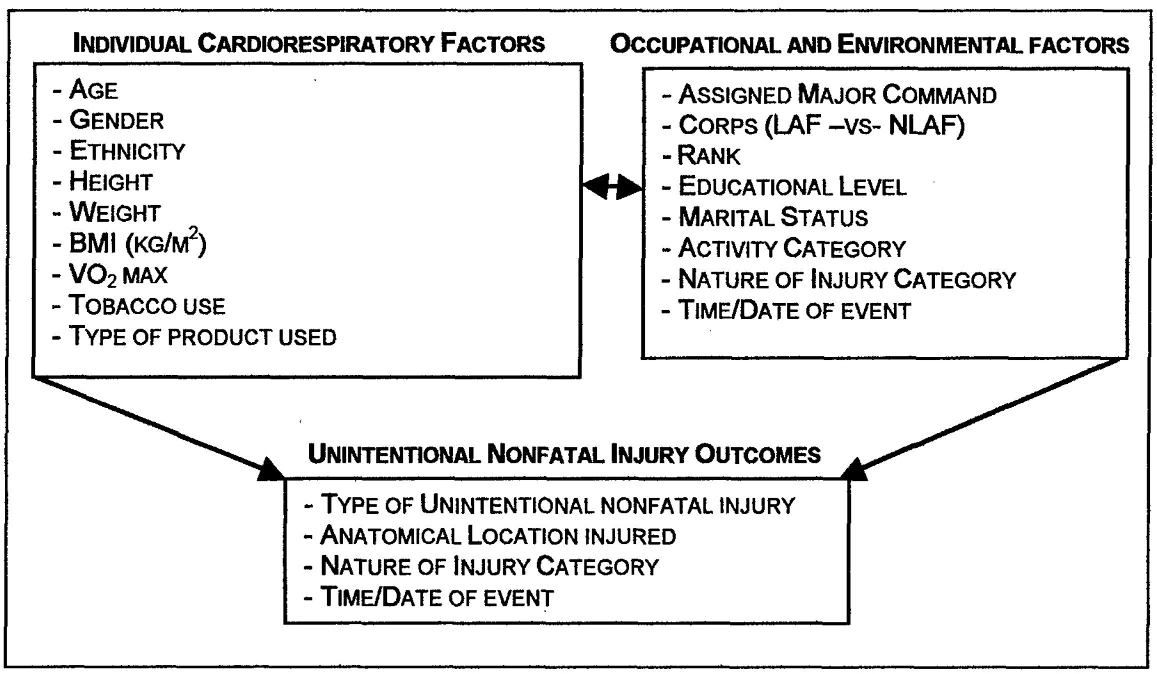
A case-control design was used to answer the research questions and test the hypotheses posed in this study. Since these questions have not been addressed in the empirical literature before, a case-control study design was employed to describe the relationship of cardiorespiratory fitness and injury. Case-control designs are useful as an exploratory method in determining the antecedents for outcomes of interest (Schlesselman, 1982). They are often the initial step undertaken by injury epidemiologists attempting to understand risk factors for outcomes that have not yet been explored. Moreover, they are less costly to carry out in terms of time and resources than are cohort studies, and they permit the simultaneous evaluation of multiple risk factors for a single injury outcome. Furthermore, they are most appropriate to the study of rare outcomes, which applies to unintentional nonfatal injuries. Finally, given the ethical considerations, the use of existing records and de-identified data, anonymity of study subjects was maintained. Thus, this study design represented very low risk to its subjects.

This observational study was principally exploratory in nature. That is, the research sought to supplement an understanding of important descriptive information regarding the association of cardiorespiratory fitness risk factors with injury. Additionally, this study contained an explanatory element. The research aimed to test directional hypotheses primarily based on both theory and results from previously empirical studies of the primary risk factors under study (Haddon, 1972; Pedhazur and Schmelkin, 1991). The results from this study may stimulate justification of new research hypotheses to be tested in future confirmatory studies.

Conceptual Model

The conceptual model in Figure 3.1 depicts the measurable relationships between the primary categories of characteristics for the ADAF cohort that likely influence or predict injury outcomes. Exposures of interest were grouped according to the model wherein host/human factors (i.e., individual cardiorespiratory factors) interacted with the occupational environmental factors that eventually predicted injury events among study subjects. Independent variables defined by occupational-specific environmental factors such as duty status, event activity, assigned Major Command (MAJCOM), and other environmental conditions (i.e., meteorological conditions, time and date of event) were summarized. The socio-demographic variables were limited to age, gender, ethnicity, level of education, rank, marital status, and corps (Line of Air Force vs. non-Line of Air Force). Additional biological characteristics that have been shown to impact injury outcomes were alcohol or drug involvement and were explored where possible.

Figure 3.1. Relationships Between *Measurable* Risk Factors and Injury-related Morbidity



Study Population and Data Sources

Study Population

The target population was the USAF active duty cohort from calendar years (CY) 1999 - 2000, inclusive. Study participants were drawn from the database of the Defense Medical Surveillance System (DMSS) maintained by the Army Medical Surveillance Activity (AMSA). A primary goal of the study was to identify injured airmen, representing cases, at their initial medical visit or hospital admission for the primary or secondary injury diagnoses of interest (in CY 2000). Among the controls, only those ADAF personnel who had a medical appointment for their annual physical examination (in CY 1999), or a component of the annual physical exam were included, as they were an adequate comparison group to the cases. Finally, the study population was further limited to ADAF airmen who had completed a cycle ergometry fitness evaluation during the study period, 1999 – 2000 and were on active duty for at least one year prior to the cycle ergometry fitness evaluation or the date of the injury.

All data provided from existing DoD and USAF databases were linked by AMSA programmers based on each study subject's unique identifiers (i.e., social security number, date of birth and name). Anonymity of the study participants was ensured by the deletion of all social security numbers and names once the database linkages were complete. After AMSA linked the databases and deleted the personal identifiers, it then provided the investigator with the master dataset. Additional precautions taken to ensure anonymity of study subjects included the analysis and reporting of data in aggregate, thereby preserving confidentiality of all airmen.

Data Sources

1. **Defense Medical Surveillance System:** Established in 1980, the Defense Medical Surveillance System (DMSS) is an administrative database that contains vast amounts of ambulatory, inpatient and mortality medical data on all service members. The Army Medical Surveillance Activity (AMSA) is a DoD functional asset that maintains the DMSS and constructed the master datasets by linking all databases

for this study. The DMSS captures data on each ADAF member's medical visit irrespective of the nature of the visit (ambulatory vs. hospitalization), as well as type of medical treatment facility (i.e., civilian vs. military). This database contains socio-demographic data on active duty airmen, diagnoses using *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) codes, anatomic region injured, external cause of injury codes (i.e., E-codes [ICD-9-CM, 1986] and STANAG codes), and the number of bed days to identify a few variables of interest. Active duty USAF personnel treated at any medical treatment facility (MTF) for any injury-relevant ambulatory visit, and/or hospitalization occurring during 2000 for diagnoses outlined in Tables 3.2 and 3.3 were eligible for inclusion as cases in the study cohort.

2. **Air Force Safety Automated System Database for Ground and Industrial Mishaps:** The Air Force Safety Center (AFSC) monitors and maintains the central electronic repository – the Air Force Safety Automated System (AFSAS) database – for reported events (termed "mishaps") that result in injury and/or fatality involving USAF personnel. The AFSAS is a passive event-based surveillance system containing a large array of data for all reported mishaps that are further delineated by overall cost of event, the number of people hospitalized, and/or severity of the injury (AFI 91-204, 2003, pp. 44-54). Independent variables of interest drawn from the AFSAS for this study are outlined in Table 3.4, and included socio-demographic data, and variables relevant to the outcome of interest such as (but not limited to) the Ground and Industrial mishap class, date of event, duty status, diagnosis (i.e., Occupational Health and Safety Agency [OSHA]), body part injured, severity of injury, length of hospitalization, associated event activity, and location of mishap (i.e., on or off base). An analysis of the risk for numerous injury conditions relative to various exposures was conducted by combining injury diagnosis identified in either the DMSS and/or the AFSAS databases.

3. **Fitness Program Support Database:** Under the direction and guidance of the Air Force Medical Operations Agency (AFMOA), the Population Health Support Office (PHSO) developed and maintained the hardware and software required for administering the annual cycle ergometry fitness assessments for all ADAF personnel. Furthermore, the PHSO maintains the USAF Fitness Program Support (FPS) database whereby installation-level fitness results for ADAF personnel were collected and archived monthly. For the purposes of this study, this database provided information on the exposure of interest (CR fitness) detailed in Table 3.4 and included: socio-demographic data for ADAF personnel, as well as annual self-reported tobacco use and type of tobacco product used, submaximal VO_2 scores (ml/kg/min), and BMI (kg/m^2) for each year of the study.
4. **Defense Manpower Data Center:** The Defense Manpower Data Center (DMDC) databases are the central repositories for military personnel data for the respective service populations and have been maintained since 1980 (Amoroso PJ, et al, 1997). Annual census information on ADAF personnel for this study was extracted from a USAF specific master file that contained archived military specific socio-demographic data on all individuals for each year of interest (i.e., 1999 and 2000). Variables of interest that were drawn from the master files included the following: gender, date of birth, race and ethnicity, education level, rank/grade, occupation – Air Force Specialty Code (AFSC), time in active federal military service, duty status, assigned USAF base and assigned MAJCOM.

Table 3.2. Army Medical Surveillance Activity Injury Diagnoses by Anatomical Region & ICD-9-CM

Head and neck
363.61 363.63 364.04 364.41 364.76 364.77 365.65 366.20 379.32 379.33 379.34 525.11 722.0 722.71 723.1 723.4 800 801 802 803 804 805.0 805.1 806.0 806.1 807.5 807.6 830 839.0 839.1 847.0 848.0 848.1 848.2 850 851 852 853 854 870 871 872 873 874 900 910.0 910.1 910.2 910.3 910.6 910.7 910.8 910.9 918 920 921 925 930 931 932
933 935.0 940 941 947.0 950 951 952.0 953.0 954.0 957.0 959.0

Shoulder and arm
354.1 354.2 354.3 716.11 716.12 716.13 718.01 718.02 718.03 718.11 718.12 718.13 718.31 718.32 718.33 718.81 718.82 718.83 718.91 718.92 718.93 719.01 719.02 719.03 719.11 719.12 719.13 719.41 719.42 719.43 726.0 726.1 726.2 726.3 727.61 727.62 733.11 810 811 812 813 818 831 832 840 841 880 881.00 881.01 881.10 881.11 881.20 881.21 887 903.0 903.1 912.0 912.1 912.2 912.3 912.6 912.7 912.8 912.9 923.0 923.1 927.0 927.1 943 953.4 955.0 955.1 955.2 955.3 955.4 955.5 955.7 955.8 955.9 959.2

Hand and wrist
354.0 716.14 718.04 718.14 718.34 718.84 718.94 719.04 719.14 719.44 726.4 727.63 727.64 733.12 814 815 816 817 833 834 842 881.02 881.12 881.22 882 883 885 886 903.4 903.5 914.0 914.1 914.2 914.3 914.6 914.7 914.8 914.9 915.0 915.1 915.2 915.3 915.6 915.7 915.8 915.9 923.2 923.3 927.2 927.3 944 955.6 959.4 959.5

Leg
716.15 716.16 718.05 718.15 718.35 718.85 718.95 719.05 719.15 719.45 726.5 727.65 733.14 733.15 733.93 808.0 808.1 820 821 823 835 843 844.3 890 897 904.0 904.1 904.2 904.3 904.5 924.0 924.10 928.0 928.10 945.00 945.04 945.06 945.09 945.10 945.14 945.16 945.19 945.20 945.24 945.26 945.29 945.30 945.34 945.36 945.39 945.40 945.44 945.46 945.49 945.50 945.54 945.56 945.59 956 959.6

Knee
717 718.36 718.86 719.06 719.16 719.46 726.6 727.66 822 836 844.0 844.1 844.2 924.11 928.11 945.05 945.15 945.25 945.35 945.45 945.55

Ankle and foot
716.17 718.07 718.17 718.37 718.87 718.97 719.07 719.17 719.47 726.7 727.67 727.68 728.71 733.94 734 824 825 826 837 838 845 892 893 895 896 904.6 917.0 917.1 917.2 917.3 917.6 917.7 917.8 917.9 924.2 924.3 928.2 928.3 945.01 945.02 945.03 945.11 945.12 945.13 945.21 945.22 945.23 945.31 945.32 945.33 945.41 945.42 945.43 945.51 945.52 945.53

Chest, back, and abdomen
720.2 721.7 722.1 722.72 722.73 724.2 724.3 724.4 724.5 724.9 733.13 805.2 805.3 805.4 805.5 805.6 805.7 806.2 806.3 806.4 806.5 806.6 806.7 807.0 807.1 807.2 807.3 807.4 808.2 808.3 808.4 808.5 808.8 808.9 809 839.2 839.3 839.41 839.42 839.51 839.52 839.61 839.71 846 847.1 847.2 847.3 847.4 847.9 848.3 848.4 848.5 860 861 862 863 864 865 866 867 868 869 875 876 877 878 879.0 879.1 879.2 879.3 879.4 879.5 879.6 879.7 901 902 911.0 911.1 911.2 911.3 911.6 911.7 911.8 911.9 922 926 934 935.1 935.2 936 937 938 939 942 947.1 947.2 947.3 947.4 952.1 952.2 952.3 952.4 953.1 953.2 953.3 953.5 954.1 954.8 954.9 959.1

Environmental
363.31 370.24 388.10 388.11 388.12 692.71 692.76 692.77 910.4 910.5 911.4 911.5 912.4 912.5 913.4 913.5 914.4 914.5 915.4 915.5 916.4 916.5 917.4 917.5 919.4 919.5 990 991 992 993 994

Unspecified

716.10 716.18 716.19 718.00 718.08 718.09 718.10 718.18 718.19 718.30 718.38 718.39 718.80 718.88 718.89 718.90 718.98 718.99 719.00 719.08 719.09 719.10 719.18 719.19 719.40 719.48 719.49 722.2 722.70 726.8 726.9 727.2 727.3 727.60 727.69 728.83 729.1 729.2 733.10 733.16 733.19 733.95 805.8 805.9 806.8 806.9 819 827 828 829 839.40 839.49 839.50 839.59 839.69 839.79 839.8 839.9 844.8 844.9 848.8 848.9 879.8 879.9 884 891 894 903.2 903.3 903.8 903.9 904.4 904.7 904.8 904.9 913.0 913.1 913.2 913.3 913.6 913.7 913.8 913.9 916.0 916.1 916.2 916.3 916.6 916.7 916.8 916.9 919.0 919.1 919.2 919.3 919.6 919.7 919.8 919.9 923.8 923.9 924.4 924.5 924.8 924.9 927.8 927.9 928.8 928.9 929 946 947.8 947.9 948 949 952.8 952.9 953.8 953.9 957.1 957.8 957.9 959.3 959.7 959.8 959.9 995.81 995.83 995.85

2/25/2004

Table 3.3. Army Medical Surveillance Activity Categories of Serious Injury

Cause	STANAG codes	Trauma code
Unintentional		
Falls and miscellaneous	900-969, 980-999	none
Land transport	100-149	none
Athletics	200-249	none
Air transport	000-059	none
Machinery, tools	600-699	none
Environmental factors	800-899	none
Poisons and fire	700-799	none
Guns, explosives, except in war	500-599	none
Water transport	150-159	none
Intentional		
Self-inflicted	none	4
Violence	970-979	2 or 3
War	300-349	0 or 1

2/25/2004

Table 3.4. Independent and Dependent Variables, Data Source, and Analyses

VARIABLE	DATA SOURCE	TYPE	ANALYSIS
DEPENDENT VARIABLES (UNINTENTIONAL NONFATAL INJURIES: OUTCOME OF INTEREST)			
Unintentional Nonfatal Injury	AFSAS* and DMSS*	Nominal (ICD-9-CM and STANAG, see Tables 3-2 & 3 for all codes)	Counts (n), range, proportions (%), median, mean ± Standard Deviation (mean ± SD), 95% Confidence Interval (95% CI), Chi-square test (χ^2), Multiple Logistic Regression (MLR) and Polychotomous Logistic Regression (PLR)
Nature or Type of Injury		Nominal (Fracture; Sprain; RTD; TBI; Hearing Loss; Open Wound; Superficial Injury, etc.)	
Anatomic Location Injured		Nominal (Head/Face/Neck; Eye; Hip/Leg; Knee; Shoulder/Arm; Spinal Column; Thorax/Abdomen; Wrist/Hand/Finger; Ankle/Foot/Toe; Body Unspecified)	
Injury Severity: - Length of Hospital Stay - Duty Days Lost		 - Continuous (Days) - Continuous (Days)	
INDEPENDENT VARIABLES (CARDIORESPIRATORY PHYSICAL FITNESS: EXPOSURES OF INTEREST)			
Height	FPS*	Continuous (meters)	n, range, %, median, mean ± SD, 95% CI, χ^2, MLR, and PLR
Weight		Continuous (kilograms)	
BMI		Continuous (kg/m^2)	
Submaximal VO_2		Continuous (ml/kg/min)	
Tobacco Use		Nominal (Dichotomous – Yes/No)	
Type of Tobacco Product		Nominal (None, Cigarettes, Smokeless, Pipe/Cigars, All Types)	
Injury Activity	AFSAS* and DMSS*	Nominal (Sports & Recreation)	
Nature of Injury		Nominal (Slip, trip, fall, struck by, walking, stationary position, running, assembling, lifting, pulling, pushing, all else)	
Time of Injury		Continuous (24 hour)	
Date of Injury		Continuous (day/month/year)	
Date of Fitness Evaluation		Continuous (day/month/year)	
INDEPENDENT VARIABLES (SOCIO-DEMOGRAPHIC CHARACTERISTICS)			
Age	DMDC*	Continuous (years)	n, range, %, median, mean ± SD, 95% CI, χ^2, MLR, and PLR
Gender		Dichotomous (male; female)	
Race/Ethnicity		Nominal (White, African-American, Hispanic, Asian, Am. Indian, All Else)	
Marital Status		Nominal (Married; Single; All Else)	
Level of Education		Ordinal (High School/GED; Some College; Bachelor; Master; Doctoral & Professional)	
Rank		Ordinal (E1-3, E4-6, E7-9, O1-3, O4-6)	
Corps		Dichotomous (LAF vs. Non-LAF)	
Assigned Major Command		Nominal (ACC, AETC, AFMC, AFSOC, AFSPC, AMC, PACAF, USAFA, USAFE, HQ/DRU/FOA/OTHER)	

* Air Force Safety Automated System (AFSAS); Defense Medical Surveillance System (DMSS); Fitness Program Support (FPS); Defense Manpower Data Center (DMDC)

Study Designs

The specific aims and related hypotheses for the overall study necessitated research designs that answered each research question. Collectively, this study used both exploratory and explanatory epidemiological designs with respective analytical methods. Each study design was based upon a population-based cohort (i.e., the active duty USAF population, 1999 and 2000) with its attendant strengths and limitations described in Chapter Five: Discussion. The first study design used an exploratory data analysis, while the latter design was a retrospective case-control study. These study designs sought to describe the types of injury events relative to the CR fitness levels among ADAF personnel, and whether differential exposures (e.g., high versus low CR fitness) are associated with differential injury outcomes (i.e., anatomic location injured and type of injury).

Data sources for this study were maintained exclusively by two Department of Defense (DoD) assets and two USAF agencies. Socio-demographic data for active duty airmen selected as participants in the retrospective case-control study were extracted from the DMDC database. The AFSAS was the source of data for independent and dependent variables of interest regarding USAF-specific reportable injuries, and the FPS database provided independent variables of interest for CR fitness exposures. Data for injury-related medical outpatient visits and hospitalizations were drawn from the DMSS that provided the additional exposure and outcome (i.e., injury diagnoses) variables of interest. Programmers from AMSA linked all database files based upon selected variables of interest for the entire study period, 1999 – 2000, and then created a master data file that excluded all personal identifiers.

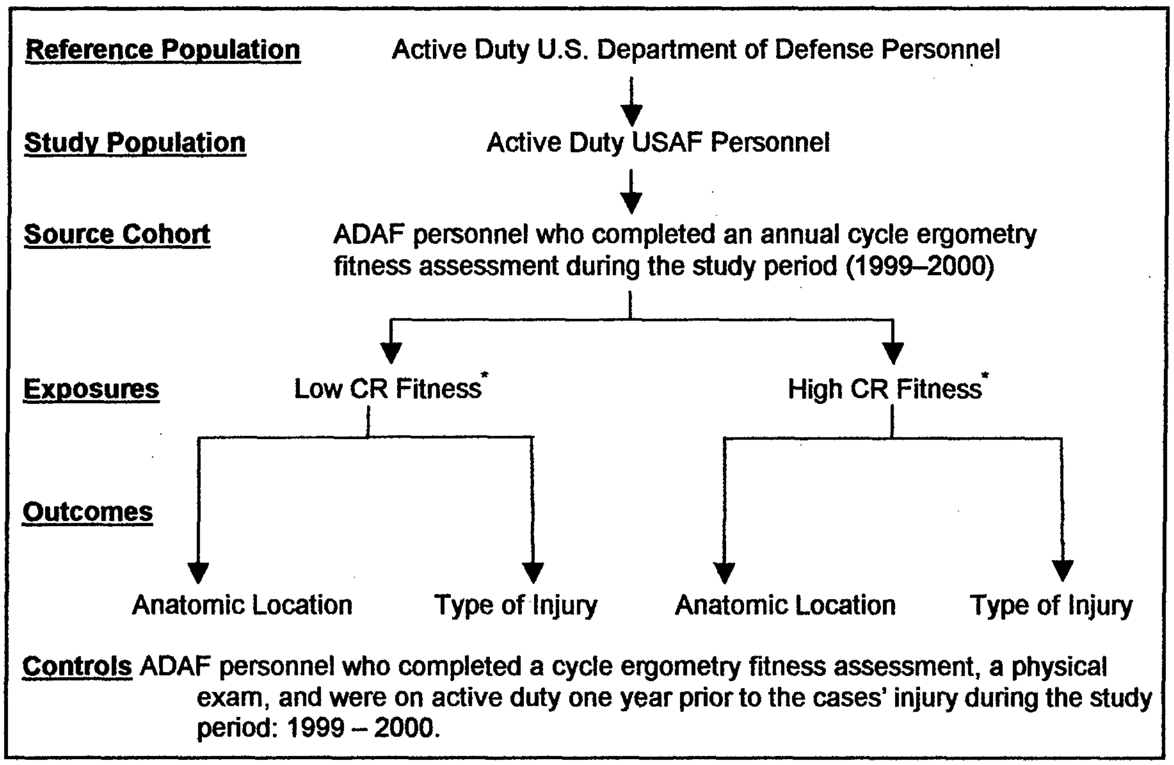
Exploratory Method: Descriptive Data Analysis

An exploratory data analysis of all dependent and independent variables selected for inclusion in the study was conducted for ADAF personnel for the period 1999 and 2000, inclusive. Both univariate and bivariate analyses of CR fitness risk factors and injuries were summarized and may be found in Chapter Four: Results. Figures 3.2 and 3.3 illustrate elements of the

exploratory study. Biologically relevant covariates were included in the final multiple regression models irrespective of their statistical significance for two reasons:

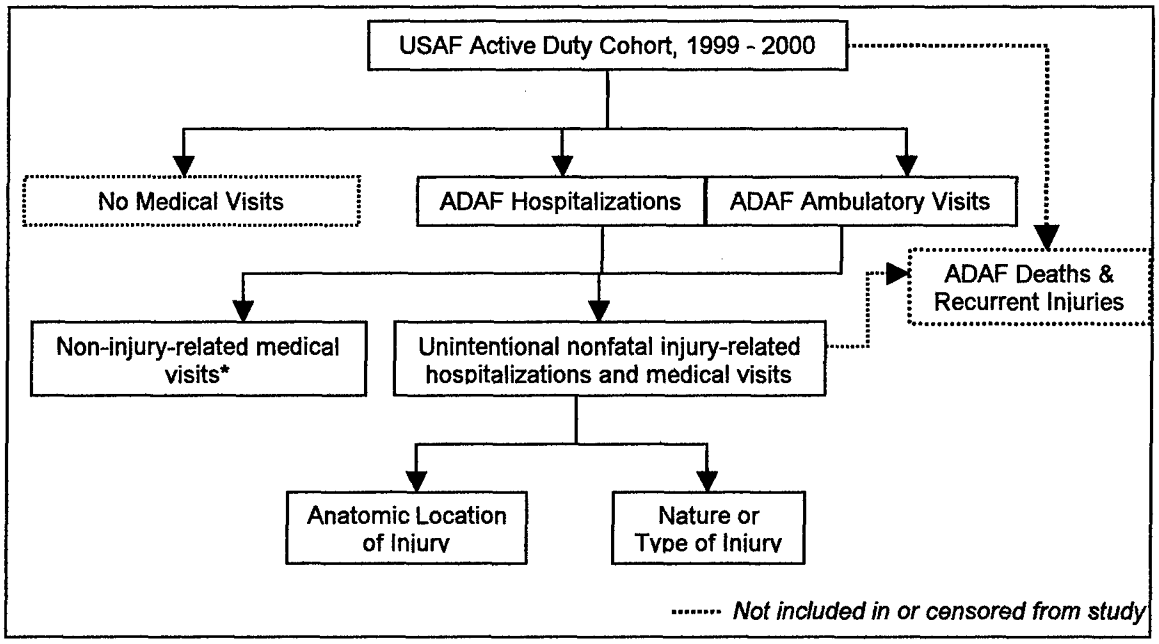
1) Results from previous studies have shown that including them is justifiable.
2) They will be identified *a priori* in the hypotheses to be tested. Figures 3.2 and 3.3 illustrate the exploratory analytic frameworks that will be used in this study.

Figure 3.2. Exploratory Analytic Framework: Cohort, Exposures and Outcomes



*NOTE: CR fitness levels (high vs. low) ascertained by age- and gender-specific submaximal VO_2 scores, and BMI are discussed in the analyses section (minimum passing values can be found in Table 3-1).

Figure 3.3. Exploratory Analytic Framework: Unintentional Nonfatal Injuries



*NOTE: The comparison population is comprised of ADAF personnel who had a medical visit for an annual physical examination, or a component of the annual physical exam (i.e., ICD-9-CM V700 or V705).

Explanatory Method: Case-Control

This study utilized a retrospective case-control study design to examine whether CR fitness risk factors are associated with injuries. The source cohort was comprised of those ADAF airmen alive at the time of the cases' nonfatal injurious event. Cases were selected from the DMSS and AFSC databases by applying the criteria for inclusion described below, and outlined in Table 3.5. The primary requirements for inclusion of cases and controls in this study design were that each airman must have been on active duty for at least one year and had a cycle ergometry fitness evaluation prior to the cases' nonfatal injury in 2000. The rationale and statistical testing plans for testing the overall hypothesis and subordinate hypotheses is outlined in Table 3.6.

Cardiorespiratory fitness (i.e., submaximal VO_{2max} scores and BMI) and activity categories (e.g., on- and off-duty sports and recreation, and ground and industrial activities) represent primary exposures of interest (i.e., independent variables) while unintentional nonfatal injuries defined by ICD-9-CM codes resulting in an ambulatory or inpatient medical visit is the dependent variable of interest. Multiple regression models were fitted to detect and control for confounding by unmatched independent variables on the dependent variables of interest. For

instance, this study explored the possibility that BMI confounds the association of ethnicity with injuries. Using a multiple logistic regression model, the relative odds of exposure to CR fitness levels (high versus low CR fitness) for injuries was analyzed separately for differences in each ethnic group's BMI risk profile.

Frequency-matching on socio-demographic variables (e.g., age, gender and race) of controls to cases was not carried out, thereby preserving the opportunity to analyze each of the independent variables for its association with the outcomes of interest. No assumptions on potential confounding were made regarding socio-demographic variables, and there was insufficient justification to match on confounders (e.g., age and gender) to improve statistical efficiency. This is particularly true since the DMDC database comprised the entire source cohort (i.e., ADAF personnel). Multiple regression analysis was used to assess for confounding, and adjusting for it when it was warranted. Figures 3.2 and 3.3 illustrate the retrospective case-control design for this study.

Table 3.5. Selection Criteria Applied to Cases and Controls

Inclusion Criteria	Selected from USAF Cohort (1999 – 2000)	
	Controls	**Cases**
On active duty (≥1 year prior to cycle ergometry evaluation)	Yes	Yes
Annual cycle ergometry evaluation (VO_2 max value) (Within 12 months of physical exam / prior to date of injury)	Yes	Yes
Medical Physical Exam (prior to date of cases' injury)	Yes	Yes
Self-reported tobacco use & type of tobacco product used	Yes	Yes
BMI (kg/m^2)	Yes	Yes
Re-Injury	N/A	Censored

Table 3.6. Study hypothesis, rationale and statistical testing scheme

STATEMENT OF PROBLEM	RATIONALE FOR ANALYSES	ANALYTIC TESTS
	PRIMARY HYPOTHESIS	
1) The cause-specific unintentional nonfatal injury rates among those with low cardiorespiratory fitness in the USAF active duty population are unknown (earlier citation).	USAF commanders and the safety community use existing databases (i.e., AFSAS) to formulate injury prevention policy and expend considerable resources on safety measures to prevent such injuries.	Bivariable analyses for the unadjusted odds of exposure; multiple regression analyses for independent effects (odds of injury controlling for other covariates) using multiple logistic regression models – cases of low CR fitness vs. USAF cohort comparison group (controls)
2) It is unknown whether low submaximal VO_2 scores and high BMI may predict unintentional nonfatal injuries in the USAF active duty population.	These physiologic and behavioral risk factors have been shown to be independent predictors for unintentional nonfatal injuries in comparable populations.	Bivariable analyses for the crude odds of exposure, stratified by anatomic region injured and injury-related activity for lost duty time; multiple regression analyses for independent effects (odds of injury controlling for other covariates) using multiple logistic regression models – cases of low CR fitness vs. USAF comparison group (controls)
3) It is unknown whether low submaximal VO_2 scores and high BMI may predict types and anatomic location of unintentional nonfatal injuries in the USAF active duty population	These risk factors have been shown to be independent predictors for increases in certain types and anatomic location of injuries (e.g., musculoskeletal: joint derangement of knee, ankle sprain, etc.) in comparable populations.	Bivariable analyses for the crude odds of anatomic region injured and type of injury; multiple regression analyses for independent effects using polychotomous logistic regression models – cases of low/high CR fitness vs. USAF comparison group (controls)

Inclusion and Exclusion Criteria

Inclusion Criteria for Cases and Controls

Active duty Air Force personnel injured during the period CY 2000 were drawn from the DMSS database, using the ICD-9-CM diagnostic codes for unintentional nonfatal injuries found in Tables 3.2 and 3.3. Additionally, cases injured during the study period were drawn from the AFSAS database, which offers detail on the activity category (i.e., on- and off-duty sports and recreation, combat training exercises, occupational, etc.) where the injury occurred and a range

of variables that contributed to understanding the nature of the injury (i.e., "slip, trip, fall, etc. categories). The DMSS database offered details similar to the AFSAS regarding the ICD-9-CM diagnoses, but contained sparse data by way of STANAG and trauma codes regarding activity categories or the nature of the injury. Combining the two databases therefore, yielded a more complete set of data describing injuries experienced by study subjects during CY 2000. Data for both cases and controls were also linked to the FPS database for their cycle ergometry fitness evaluations for the years 1999 and 2000. Several factors defined inclusion criteria for subjects in this study:

1. They must have completed a cycle ergometry assessment prior to the cases' medical visit or hospitalization for an injury during the period (CY 1999 for the controls, and 2000 for the cases).
2. They must have a submaximal VO_{2max} score not equal to zero (i.e., a valid score).
3. Have completed one full year of active duty service prior to the date of the cycle ergometry fitness evaluation.
4. Among cases, they must have been treated for a specific injury-related medical condition during the calendar year 2000 (see Tables 3.2 and 3.3 for ICD-9-CM codes).
5. Among cases, they must have completed an annual physical examination (ICD-9-CM V700 or V705) in the CY 1999.
6. Among the controls, they must have completed an annual physical examination or a component of the annual physical examination prior to the date of the cases' injury in CY 2000.
7. Among the controls, they must have completed the physical examination within one calendar year (1999) of their cycle ergometry fitness evaluation.

Exclusion criteria for cases and controls

Air Force personnel who had received a medical exemption from annual cycle ergometry fitness evaluations for conditions that either placed them at risk for cardiovascular collapse or would otherwise impair accurate fitness assessments were excluded from this study (AFI 40-501, 2002; AFI 48-123, 2001). Confirmed cases of pregnancy were excluded from this study since pregnant women were medically exempt from cycle ergometry fitness evaluations for the duration of the pregnancy and six months postpartum. All confirmed cases of any injury-related fatality (i.e., unintentional injury fatality, homicide, interpersonal violence, or assault), suicide (i.e., completed, attempt, and injuries related to suicide attempts), and poisonings were excluded from this study. Finally, while it was possible to identify cases of re-injury with the combined databases, this study was limited to an initial injury per airman during the study period. Thus, only incident injury cases were included, and censored thereafter. See Table 3.5 for inclusion/exclusion criteria of cases and the controls.

Measurement

Variables for Analyses

Dependent Variables (outcomes of interest)

The selected dependent variables for this study include: unintentional nonfatal injuries – anatomic location injured (e.g., hip/leg, wrist/hand/finger, etc.) and the nature or type of injury (e.g., fracture, sprain, etc.) among ADAF personnel during 2000 (see Table 3.4). Within this study, injuries include acute/incident medical conditions that may have similar clinical presentations as chronic/overuse conditions, although the diagnostic category codes differ given particular circumstances for the injury. Only cases of incident injuries were compared to active duty airmen – the controls – who were not injured in terms of environmental, individual and behavioral characteristics. Analyses of dichotomized CR risk factors (high versus low) among the

injured cases relative to the uninjured were performed. Where the analysis revealed significant risk profiles that are amenable to prevention or intervention practices, recommendations for altering or enforcing existing policies were explored.

Independent Variables (risk factors of interest)

Central to the research question was how, if at all, low or high CR fitness levels were associated with injuries among active duty airmen. Low CR fitness was defined as a submaximal VO_{2max} score less than the USAF minimum passing values for VO_{2max} in ml/kg/min by age and gender (Table 3.1). An additional, yet proxy measure for low CR fitness is a body mass index (BMI) equal to or exceeding 30 kilograms per meter squared (BMI ≥ 30 kg/m^2), and was explored using bivariate and multiple regression analyses. Furthermore, BMI values were divided into four categories: Underweight, Normal, Overweight, or Obese, according to the clinical guidelines outlined by the National Institutes of Health for BMI values (see Table 3.7). Other proxy measures that were investigated in bivariate and regression analyses were self-reported tobacco use and type of tobacco product used. In contrast, proxy measures for high CR fitness that were explored in bivariate and multiple regression analyses included a body mass index (BMI) less than 25 kilograms per meter squared (BMI < 25 kg/m^2) and no tobacco use. Table 3.4 summarizes the independent variables that were included in univariate, bivariate and multiple regression analyses.

Table 3.7. Standard Values for BMI and Weight Status

BMI (kg/m^2)	Weight Status
≤ 19.9	Underweight
20.0 – 24.9	Normal (Desirable)
25.0 – 29.9	Overweight
≥ 30.0	Obese

SOURCE: National Heart, Lung, and Blood Institute website. Last accessed on 7/2005 at: http://www.nhlbi.nih.gov/health/public/heart/obesity/lose_wt/profmats.htm

Confounders and Effect Modifiers

In epidemiological studies such as this retrospective case-control study, confounders are defined as variables that are associated with the exposure in the source population, associated with the injury but is not a consequence of CR fitness exposure, and not in the causal pathway between CR fitness exposure and injury (Szklo M & Nieto FJ, 1999). It is an extraneous variable that masks the underlying association. Statistical associations, comparing unadjusted and adjusted effect estimates (where a relative change after adjustment greater than 10 percent was observed was indicative of a confounding variable) were used to identify and adjust for potential confounders.

The presence of interactions was explored using the regression coefficients for each covariate of interest from the multiple linear and logistic regression models. Interaction coefficients measure how much an association between injury and an independent variable (e.g., BMI) differs across levels of another predictor (e.g., ethnicity). For example, if tobacco use modifies the odds of injury and failing submaximal VO_{2max} scores, the odds ratio for failing submaximal VO_{2max} scores and injury would differ among tobacco users and non-users. Particular analytic focus on variables (e.g., age, gender, race/ethnicity, and rank) for the presence of interactions were explored, and significant differences in the fit of the model with and without interaction terms were addressed. In summary, investigating independent variables that were expected to confound or interact with the dependent variables preceded the development of the final multiple regression models.

Missing data

In general, the DoD and USAF administrative databases were relatively complete. However, missing data for variables of interest were identified, and where data from one database was missing, the other databases were exploited to provide the missing data. The degree of missing data for all covariates is illustrated in Tables 4.1– 4.3 (see Chapter 4: Results). Height, weight and BMI were drawn solely from the USAF FPS database and did not pose a

particular concern in that less than two percent of these variables contained missing data. Additionally, annually, approximately 35% of Class C mishaps, injuries to USAF personnel resulting in a minimum of one lost duty day are by definition reportable to the AFSC, but were not recorded in the AFSAS. These mishaps typically occurred on weekends and often did not result in a lost duty day (Copley BC, Burnham B, Shim M, 2003). Although missing data for these injuries were a form of selection bias and therefore, are a threat to the study's internal validity, minimizing such bias was accomplished through the retrieval of all reportable injuries not otherwise recorded in the AFSAS from the DMSS.

Summary analysis for missing variables preceded any statistical modeling that included them. The method for imputing a missing continuously coded value is to use the mean of known values for that particular variable given other parameters; however, it reduces the variance, but does yield an unbiased estimate of the numerator in statistical methods such as the t-test. For missing nominal or ordinal variables, it was not possible to estimate the missing value using other variables as predictors through multiple regression models in this study. Therefore, observations where data were missing or miscoded were excluded from this study, and subsequently, from all statistical models.

Data Analyses

Descriptive exploratory elements

Using the DoD administrative and epidemiological databases described earlier, proportions of injuries were described for ADAF personnel for the period CY 2000. Independent variables in the bivariate analysis (i.e., Chi-square test) included categories of socio-demographic characteristics and exposures of interest (Chapter 4: Results). The study subjects (cases vs. controls) stratified by gender were reported in tabular format (Chapter 4: Results).

Explanatory elements (Unintentional nonfatal injuries)

In this study, the calculation of the odds of CR fitness exposure began with any medical visit for any injury. Measures of central tendency were summarized for all continuously coded (quantitative) covariates, whereas categorical variables were analyzed using $k \times 2$ tables depicting the proportion of cases and controls (Chapter 4: Results). Separate bar graphs for CR risk factors were used to illustrate injuries by certain categorical variables (Chapter 4: Results). These initial exploratory analyses provided insight into analytical procedures that required further statistical analysis.

In addition to fitting multiple logistic regression models to the data explained thus far, separate polychotomous logistic regression models were fitted to explore the relationships between CR fitness and the type/nature of injury and the anatomic location of the injury. The following steps were taken to ensure that selected independent variables were fully explored in relation to the outcome of interest before fitting final multiple and/or polychotomous logistic regression models:

1. Relationships between variables were examined using $k \times 2$ tables and the Chi-square test (χ^2) for association. Results of a simple logistic regression to estimate the unadjusted (crude) relative odds of having each socio-demographic characteristic or exposure, and the 95 percent confidence interval (95% CI) for those estimates, are displayed in (Chapter 4: Results). The testable hypotheses dictated that all biologically relevant terms identified *a priori* were used in the multiple logistic and linear regression models regardless of the statistical significance (e.g., $p \leq 0.05$ level) achieved from bivariate analyses.
2. A linear model was fitted containing the quantitative covariates and interaction terms, and then, assessed for collinearity between them (e.g., age and rank) using the variance inflation factor (VIF). A VIF of 10 or greater was indicative of increasingly higher levels of collinearity between the measured covariates. Therefore, interaction terms with high VIF values were not used when fitting the final multiple logistic or linear regression models. Additionally, the relationship of the quantitative covariates

to the response variables was examined for linearity (determined through analysis and graphing), and it was deemed unnecessary to convert variables into spline terms.

3. Hosmer and Lemeshow's goodness-of-fit tests were indicated due to the many covariate patterns observed relative to the sample size. (Hosmer DW & Lemeshow S, 2000).
4. Prior to fitting the final model, assumptions under which multiple logistic regression may be used were met, and are as follows
    a) For a given pattern of the CR fitness predictors (submaximal VO_{2max} values and BMI), the injury outcomes have a binomial distribution (i.e., unintentional nonfatal injuries vs. no injury) with a mean that approximates the mean of the source USAF cohort [i.e., μ_i = prob(Y_i = 1)]. In addition, the injury outcomes (Y_i) were independent of each other; in that, each injury was not correlated to another. Given that the pattern of CR fitness predictors result in binomially-distributed injury outcomes, and that the injuries are independent of each other, the implication is that the variance of the injury outcomes was equivalent to the product of the population mean and one minus the population mean [i.e., $Var(Y_i) = \mu_i(1 - \mu_i)$].
    b) Appropriate regression diagnostics were performed applying the following rationale:
        1) To evaluate the randomness of the model's residuals,
        2) The use of adjusted variables plots to study the association of injury with a particular independent variable (adjusting for all other independent variables),
        3) The model's robustness (i.e., how well it fits the complete data), and
        4) Its resistance (i.e., influence of extreme values for independent and dependent variables).

Separate multiple and polychotomous logistic regression models described by Hosmer and Lemeshow (2000) were fitted to assess the covariates for independent associations for injury outcomes (i.e., multiple logistic regression was used for dichotomized injury vs. no injury; multinomial logit regression was used for polychotomous injury outcomes: anatomic location and nature of injury categories vs. no injury) (Hosmer DW & Lemeshow S, 2000). All analyses adjusted for socio-demographic and other independent covariates, and included interaction terms and confounders identified in earlier analyses. Likelihood ratio tests (LRT) were used to test the joint significance of the coefficient that was a surrogate measure for cardiorespiratory fitness (i.e., BMI) in alternative nested mathematical models. The final, most parsimonious, model included all terms found to be statistically significant ($p \leq 0.05$), any confounding covariates, interaction terms and those independent variables specified by the hypotheses (i.e., covariates identified *a priori*).

The equation that will be used for LRT is as follows:

$$-2(LL_N - LL_E)$$

where LL_N = log likelihood of the null model & LL_E = log likelihood of the extended model.

CHAPTER 4. RESULTS

Introduction

This chapter reports the results of the study and analysis of the data. Dataset construction is reported first. Second, descriptive statistics of the study subjects are reported and third, the results from the bivariate and multivariate analyses are presented. Fourth, hypothesis testing for all research questions are reported via results of the multiple logistic regression. Finally, this chapter concludes with the results from analysis using multinomial logit regression models reported as additional findings.

Dataset Construction

Missing Values and Coding Errors

The master data files from the Defense Medical Surveillance System (ambulatory and inpatient visits), the Air Force Safety Automated System (reported Ground and Industrial Mishaps), and the Fitness Program Support Database (cycle ergometry evaluations) were merged on the common study identification number (i.e., the de-identified social security number). After the inclusion and exclusion criteria described in Chapter Three were applied, an initial 73,577 observations were considered in this study. Miscoded values for height, weight, and BMI were assessed by subtracting its value taken from the injury study period (CY 2000) from the value obtained during the injury-free study period (CY 1999). Deviations of plus or minus two inches for height, and plus or minus 30 pounds for weight were considered coding errors (e.g., data entry error). Since BMI and submaximal VO_{2max} scores were calculated from height, weight, age, and gender at the time of the cycle ergometry fitness evaluation, excluding observations where height and weight were improperly coded from the study automatically eliminated any

observation with miscoding for BMI and submaximal VO_{2max} scores calculated from them. Furthermore, observations whose age was greater than 62 years were excluded from the study (n = 2) since they were likely a result of a coding error. For any one covariate, the proportion of missing or improperly coded values was less than one percent of the total. Overall, the proportion of missing or miscoded values totaled 0.31 percent (n = 225). The total number of observations was reduced to 73,352 after excluding observations with missing or miscoded values (see Tables 4.1–3).

Table 4.1. Missing values for All Covariates

Covariate	Number Missing	Percent Missing*
Sex	0	0
Age	124	0.17
Ethnicity	0	0
Education Level	0	0
Marital Status	0	0
Rank	0	0
Corps (Line vs. Nonline)	81	0.11
Diagnosis	0	0
Height	27	0.026
Weight	27	0.026
Body Mass Index	27	0.026
Tobacco Use	0	0
Tobacco Product	0	0
$VO_{2\,max}$ Score	0	0
MAJCOM	0	0

***N = 73,577**

Table 4.2. Missing values for Covariates Among Controls

Covariate	Number Missing	Percent Missing*
Sex	0	0
Age	92	0.28
Ethnicity	0	0
Education Level	0	0
Marital Status	0	0
Rank	0	0
Corps (Line vs. Nonline)	47	0.14
Diagnosis	0	0
Height	14	0.04
Weight	14	0.04
Body Mass Index	14	0.04
Tobacco Use	0	0
Tobacco Product	0	0
$VO_{2\,max}$ Score	0	0
MAJCOM	0	0

***N = 33,261**

Table 4.3. Missing values for Covariates Among Cases

Covariate	Number Missing	Percent Missing*
Sex	0	0
Age	32	0.08
Ethnicity	0	0
Education Level	0	0
Marital Status	0	0
Rank	0	0
Corps (Line vs. Nonline)	34	0.08
Diagnosis	0	0
Height	13	0.03
Weight	13	0.03
Body Mass Index	13	0.03
Tobacco Use	0	0
Tobacco Product	0	0
$VO_{2\,max}$ Score	0	0
MAJCOM	0	0

***N = 40,316**

Outliers

After removing miscoded and missing values, a visual inspection of the data via Tukey's box-and-whisker plots and scatter plot matrices of the continuously coded covariates were carried out. First, the plots were inspected using all observations (n = 73,352) and then, separate plots

of cases versus controls, male versus females, and enlisted versus officers were assessed. The goal of these techniques was to identify problematic observations and consider their removal. An additional goal of conducting these preliminary analyses was to identify any violations of the assumptions upon which the regression models are based.

Inclusion was based upon accession standards for height, weight, and age among men and women established in Air Force Policy Directive 40-5: *Fitness and Weight Management*, 1 Dec 1997. Additional consideration was given to observations that met the standards based upon Air Force Instructions (AFI) AFI 40-501: *The Air Force Fitness Program*, 5 Apr 2002, and AFI 40-502: *The Weight and Body Fat Management Program*, 3 Apr 2002. While accession standards apply to the majority of the population considered for active duty service, there are numerous instances when they may be waived (e.g., minimum and maximum height for men and women). Furthermore, comparisons to determine general representativeness of the study participants to the Air Force overall were limited to officers in the company and field grade ranks (Second Lieutenant to Colonel; O1 – O6) because demographic information on general officers could not be obtained. After applying these criteria, 622 more observations were excluded, reducing the total number of observations in this study to 72,730.

Sensitivity Analysis

A sensitivity analysis comparing the likelihood for injury of the study population taken from the first quarter (January – March, inclusive) of CY 2000 with the probability of injury among the entire study population taken from the entire calendar year was performed using two separate multiple logistic models. The justification for the sensitivity analysis was predicated on the assumption that case selection in the early part of the calendar year relative to the entire year may have been biased. That is, there was a need to test the assumption that cases had just as much opportunity for inclusion in the study late in the year as they did in the first quarter. The results from the logistic regression models did not meaningfully differ between those injured early versus later in the year (results not shown). Therefore, statistical analyses described below were carried out on all 72,730 observations.

Descriptive Statistics

Sample Generalizability

Comparing the study participants to the USAF population overall in 1999, the distributions of active duty males and females were similar, as were the majority of the major age groups. However, there were approximately 4% more study subjects in the 21 – 25 year age group and 3% fewer subjects in the 31 – 35 year age group relative to the USAF active duty population. The proportion of officers (O1 – O6) and senior enlisted personnel (i.e., E7 – E9) were underrepresented in this study by nearly half that of the USAF population. Marital status and highest level of education attained among study subjects was comparable to that of the USAF population's marital status and education levels. Distributions of study subjects by USAF Major Command only slightly differed from that of the USAF ranging from 4.5% (higher in AETC for the USAF population) to one percent in other commands. African Americans in this study were proportionally distributed relative to the USAF active duty population (15%). Finally, Caucasians and Asians were under-represented in this study relative to the ADAF population while Hispanics were over-represented by nearly twice that of the active duty force.

Univariate Statistics

Tables 4.4–9 summarize the demographic characteristics of the study participants. The distribution of age, BMI, and submaximal VO_2 values are positively skewed among all study subjects. Additionally, there were observable differences in the ranges and mean values between cases and controls, and between men and women. Generally, the cases were older than the controls, but that difference is largely due to the fact that cases were selected the year (CY 2000) following the year of selection for controls (CY 1999). Proportionally, males (mean age = 30.8 yrs) are older than females (mean age = 28.3). Although fifty-six percent of the cases were categorized as overweight or obese compared to only 52% of the controls, there were negligible differences between mean BMI among cases and controls (25.5 versus 25.2 kg/m^2). However, 60% of males (cases and controls) were overweight or obese compared to nearly 29% of the females. While there was little difference in mean values for submaximal VO_2 scores

between cases and controls, nearly 87% of the cases passed their fitness evaluation versus only 82% of the controls. Slightly less than 92% of the women passed their annual fitness evaluation compared to only almost 83% of the male study participants. Proportions of tobacco use did not vary across cases and controls (71%), but fewer women then men used tobacco products (77% versus 70%, respectively).

Regarding demographic covariates comparing cases to controls, there were more active duty males among the controls (82.5 versus 80.6 percent), active duty Hispanics (14% versus 8%) and officers (22% versus 12%), respectively. However, there were fewer Caucasians among controls than cases (66% versus 70%), and 33% of the controls were single, whereas nearly 73% of the cases were currently or previously had been married. A larger proportion of the cases had attained their high school education or equivalent (n = 4,762; 12%) compared to the controls (n = 1,344; 4%). Negligible differences were found in the distribution of Line (LAF) versus Non-line of the Air Force (NLAF) active duty personnel.

When these covariates are stratified by gender, the distributions differ substantially. Almost 50% of the active duty female cases and controls were less than age 25 years whereas the median age for males is approximately 30 years. Slightly over 28% of men were single compared to 38% of females. Nearly 11% of men had attained an education level at least a Master degree compared to only nine percent of active duty women. Males were larger in number and proportion in the LAF (n = 54,335; 91.7%) compared to women in the LAF (n = 9,799; 72.6%). Only 16.6% of the women were officers compared to 18.4% of the men, and there were nearly twice the proportion of women in the lowest enlisted group (E1 – E3) compared to that of men (37.3 versus 18.9%).

Table 4-10 summarizes the distribution of injuries by anatomic location and nature of injury while Figures 4-1–6 use histograms to depict the proportional distributions of injury categories by gender (male vs. female), corps (LAF vs. NLAF), and rank (enlisted vs. officer). The largest proportion of total injuries stratified by anatomic location experienced by ADAF personnel in 2000 were injuries to the spinal column (24.6%), nonspecific body location (19.1%), upper arm and shoulder girdle (11.8%), ankle, foot, and toe (11.3%), and wrist, hand, and fingers

(9.6%). Injuries to the knee, pelvic girdle and lower leg comprised fifteen percent of the total by anatomic location. Stratified by type or nature of injury, sprains comprised the largest proportion of the total (24.4%), followed by lumbago and backache (18.4%), injuries to joints (18%) and repetitive trauma disorders (11%). Occupationally- and non-occupationally-related conditions such as, noise-induced hearing loss comprised less than one percent of the total injuries experienced, and injuries resulting from environmental effects (e.g., hypothermia, sunburn, etc.) were slightly over one percent of the total number of injuries.

The distribution of injuries by injury categories stratified by gender differed only slightly, illustrated by histogram (see Figures 4.1 and 2). Women and men experienced more injuries to their spinal column than any other anatomic location (17% and 13%, respectively), most of which were lumbago and backache injuries (12.5% and 9.5%, respectively). Men and women had nearly the same percentage of sprains and joint-related injuries proportional to the total number of injuries for each gender (13% and 10%, respectively). Stratified by Corps, the greatest proportion of injuries experienced by the Nonline of the Air Force (NLAF: medical, legal, and chaplains) and Line of the Air Force (LAF) were to the spine (15.9% versus 13.1%, respectively). Additionally, NLAF and LAF active duty personnel had more sprains, joint-related and lumbago/backache injuries than other injury types (35.4% and 32.9%, respectively). Finally, when stratified by major rank groups (i.e., enlisted versus officer), enlisted and officers experienced a higher proportion of injuries to the spinal column, 14.1% versus 10.4%, relative to injuries among all enlisted and officers, respectively. Sprains, joint-related and lumbago/backache injuries comprise the largest proportion of injuries among enlisted and officers, 37% and 25%, respectively.

Table 4.4. Baseline Characteristics Among Air Force Active Duty (ADAF), 1999

Covariate	n (%)*	Mean (±SD)	Range	95% CI
Age (≥ 17 yrs)	72,730	30.2 (± 7.7)	17.7 – 61.0	30.1 – 30.2
Age Groups (yrs)				
17 – 20	7,962 (10.9)	–	–	–
21 – 25	20,538 (28.2)	–	–	–
26 – 30	13,761 (18.9)	–	–	–
31 – 35	11,210 (15.4)	–	–	–
36 – 40	12,614 (17.3)	–	–	–
41 – 45	4,939 (6.8)	–	–	–
46 – 50	1,364 (1.9)	–	–	–
51+	342 (0.5)	–	–	–
Gender				
Male	59,234 (81.4)	–	–	–
Female	13,496 (18.6)	–	–	–
Race				
White	49,648 (68.3)	–	–	–
Black	10,948 (15.1)	–	–	–
Hispanic	7,899 (10.9)	–	–	–
Asian	2,206 (3.0)	–	–	–
Am. Indian	529 (0.7)	–	–	–
All Else	1,500 (2.0)	–	–	–
Marital Status				
Married	45,251 (62.2)	–	–	–
Single	22,478 (30.9)	–	–	–
All Else	5,001 (6.9)	–	–	–
Education Level (Highest Attained)				
High School/GED	8,025 (11.0)	–	–	–
Some College	48,574 (66.8)			
Bachelor Degree	8,665 (11.9)	–	–	–
Master Degree	5,850 (8.0)	–	–	–
PhD/Professional Degree	1,616 (2.2)	–	–	–
Corps				
Line of the Air Force	64,134 (88.2)	–	–	–
Non-line of the Air Force	8,596 (11.8)	–	–	–
Rank Group				
E1 – E3	14,903 (20.5)	–	–	–
E4 – E6	36,553 (50.3)	–	–	–
E7 – E9	8,150 (11.2)	–	–	–
O1 – O3	7,802 (10.7)	–	–	–
O4 – O6	5,322 (7.3)	–	–	–

Table 4.5. Baseline Demographic and CR Fitness Characteristics Among ADAF, 1999

Covariate	n (%)*	Mean (±SD)	Range	95% CI
Major Command				
ACC	19,280 (26.5)	–	–	–
AETC	11,207 (15.4)	–	–	–
AFMC	7,258 (10.0)	–	–	–
AFSOC	1,963 (2.7)	–	–	–
AFSPC	3,928 (5.4)	–	–	–
AMC	11,823 (16.3)	–	–	–
HQ/DRU/FOA/OTHER	6,133 (8.4)	–	–	–
PACAF	6,103 (8.4)	–	–	–
USAFA	490 (0.7)	–	–	–
USAFE	4,545 (6.2)	–	–	–
Tobacco Use	72,730	–	–	–
None	52,056 (71.6)	–	–	–
Cigarettes	15,571 (21.4)	–	–	–
Smokeless	3,032 (4.2)	–	–	–
Pipe/Cigar	931 (1.3)	–	–	–
All Types	1,140 (1.6)	–	–	–
Body Mass Index (kg/m^2)		25.3 (± 3.3)	15.0 – 50.7	25.3 – 25.3
Underweight (< 20)	3,647 (5.0)	–	–	–
Normal Weight (20 – 24.99)	30,081 (41.4)	–	–	–
Overweight (25 – 29.99)	33,324 (45.8)	–	–	–
Obese (≥ 30)	5,678 (7.8)	–	–	–
VO_2 Max Values (ml/kg/min)		37.6 (± 8.0)	15 – 80	37.5 – 37.6
Pass	60,970 (83.8)	–	–	–
Fail	11,760 (16.2)	–	–	–

Table 4.6. Demographic Characteristics Among ADAF Men & Women, 1999

Covariate	Men n (%)	Mean (±SD)	Range	Women n (%)	Mean (±SD)	Range
Age (≥ 17 yrs)	59,234	30.8 (± 7.8)	17.7 – 61.7	13,496	28.3 (± 7.3)	17.9 – 61.1
Age Groups (yrs)						
17 – 20	5,047 (8.5)	–	–	1,832 (13.6)	–	–
21 – 25	15,901 (26.8)	–	–	4,895 (36.3)	–	–
26 – 30	11,231 (19.0)	–	–	2,758 (20.4)	–	–
31 – 35	9,429 (15.9)	–	–	1,574 (11.7)	–	–
36 – 40	11,468 (19.4)	–	–	1,466 (10.9)	–	–
41 – 45	4,552 (7.7)	–	–	720 (5.3)	–	–
46 – 50	1,285 (2.2)	–	–	206 (1.5)	–	–
51+	321 (0.5)	–	–	45 (0.3)	–	–
Race						
White	41,482 (70.0)	–	–	8,166 (60.5)	–	–
Black	7,932 (13.4)	–	–	3,016 (22.4)	–	–
Hispanic	6,527 (11.0)	–	–	1,372 (10.2)	–	–
Asian	1,719 (2.9)	–	–	487 (3.6)	–	–
Am. Indian	399 (0.7)	–	–	130 (0.9)	–	–
All Else	1,175 (2.0)	–	–	325 (2.4)	–	–
Marital Status						
Married	38,941 (65.7)	–	–	6,746 (50.0)	–	–
Single	16,753 (28.3)	–	–	5,140 (38.1)	–	–
All Else	3,540 (6.0)	–	–	1,610 (11.9)	–	–
Education (Highest Attained)						
High School/GED	4,878 (8.2)	–	–	1,223 (9.1)	–	–
Some College	40,932 (69.1)	–	–	9,437 (69.9)	–	–
Bachelor Degree	7,047 (11.9)	–	–	1,671 (12.4)	–	–
Master Degree	5,056 (8.5)	–	–	863 (6.4)	–	–
PhD/Professional Degree	1,321 (2.2)	–	–	302 (2.2)	–	–
Corps						
Line of the Air Force	54,335 (91.7)	–	–	9,799 (72.6)	–	–
Non-line of the Air Force	4,899 (8.3)	–	–	3,697 (27.4)	–	–
Rank Group						
E1 – E3	11,220 (18.9)	–	–	3,683 (27.3)	–	–
E4 – E6	29,830 (50.4)	–	–	6,723 (49.8)	–	–
E7 – E9	7,307 (12.3)	–	–	843 (6.3)	–	–
O1 – O3	6,220 (10.5)	–	–	1,582 (11.7)	–	–
O4 – O6	4,657 (7.9)	–	–	665 (4.9)	–	–

Table 4.7. Demographic & CR Fitness Characteristics Among ADAF Men & Women, 1999

Covariate	Men n (%)	Mean (±SD)	Range	Women n (%)	Mean (±SD)	Range
Major Command	59,234			39,688		
ACC	15,974 (27.0)	–	–	3,306 (24.5)	–	–
AETC	8,835 (14.9)	–	–	2,372 (17.6)	–	–
AFMC	5,810 (9.8)	–	–	1,448 (10.7)	–	–
AFSOC	1,727 (2.9)	–	–	236 (1.7)	–	–
AFSPC	3,279 (5.5)	–	–	649 (4.8)	–	–
AMC	9,711 (16.4)	–	–	2,112 (15.6)	–	–
HQ/DRU/FOA/ OTHER	4,837 (8.2)	–	–	1,296 (9.6)	–	–
PACAF	5,028 (8.5)	–	–	1,075 (8.0)	–	–
USAFA	343 (0.6)	–	–	147 (1.1)	–	–
USAFE	3,690 (6.2)	–	–	855 (6.3)	–	–
Tobacco Use						
None	41,413 (69.9)	–	–	10,380 (76.9)	–	–
Cigarettes	12,744 (21.5)	–	–	3,031 (22.5)	–	–
Smokeless	3,027 (5.1)	–	–	12 (0.1)	–	–
Pipe/Cigar	952 (1.6)	–	–	47 (0.3)	–	–
All Types	1,098 (1.9)	–	–	26 (0.2)	–	–
Body Mass Index (kg/m^2)		25.8 (±3.2)	15.0 – 50.1		23.4 (±3.0)	15.4 – 45.2
Underweight (< 20)	1,980 (3.3)	–	–	1,634 (12.1)	–	–
Normal (20 – 24.99)	21,354 (36.1)	–	–	8,244 (61.1)	–	–
Overweight (25 – 29.99)	30,393 (51.3)	–	–	3,311 (24.5)	–	–
Obese (≥ 30)	5,507 (9.3)	–	–	307 (2.3)	–	–
VO_2 Max Values (ml/kg/min)		38.2 (±7.8)	15 – 80		34.8 (±7.8)	15 – 77
Pass	49,096 (82.9)	–	–	12,367 (91.6)	–	–
Fail	10,138 (17.1)	–	–	1,129 (8.4)	–	–

Table 4.8. Demographic Characteristics Among Cases and Controls, 1999 – 2000

Covariate	Controls n (%)	Mean (±SD)	Range	Cases n (%)	Mean (±SD)	Range
Age (≥ 17 yrs)	33,042	29.5 (±7.7)	17.7 – 61.0	39,688	30.7 (±7.7)	17.9 – 61.7
Age Groups (yrs)						
17 – 20	5,047 (8.5)	–	–	3,529 (8.9)	–	–
21 – 25	15,901 (26.8)	–	–	10,952 (27.6)	–	–
26 – 30	11,231 (19.0)	–	–	7,225 (18.2)	–	–
31 – 35	9,429 (15.9)	–	–	6,283 (15.8)	–	–
36 – 40	11,468 (19.4)	–	–	7,625 (19.2)	–	–
41 – 45	4,552 (7.7)	–	–	3,054 (7.7)	–	–
46 – 50	1,285 (2.2)	–	–	821 (2.1)	–	–
51+	321 (0.5)	–	–	199 (0.5)	–	–
Gender						
Male	27,261 (82.5)	–	–	31,973 (80.6)	–	–
Female	5,781 (17.5)	–	–	7,715 (19.4)	–	–
Race						
White	21,777 (65.9)	–	–	27,871 (70.2)	–	–
Black	4,701 (14.2)	–	–	6,247 (15.7)	–	–
Hispanic	4,657 (14.1)	–	–	3,242 (8.2)	–	–
Asian	1,076 (3.3)	–	–	1,130 (2.9)	–	–
Am. Indian	201 (0.6)	–	–	328 (0.8)	–	–
All Else	630 (1.9)	–	–	870 (2.2)	–	–
Marital Status						
Married	20,062 (60.7)	–	–	25,625 (67.6)	–	–
Single	10,995 (33.3)	–	–	10,898 (27.5)	–	–
All Else	1,985 (6.0)	–	–	3,165 (7.9)	–	–
Education (Highest Attained)						
High School/GED	1,344 (4.1)	–	–	4,762 (12.0)	–	–
Some College	23,503 (71.1)	–	–	26,861 (67.7)	–	–
Bachelor Degree	4,448 (13.4)	–	–	4,270 (10.7)	–	–
Master Degree	2,827 (8.6)	–	–	3,092 (7.8)	–	–
PhD/Professional Degree	920 (2.8)	–	–	703 (1.8)	–	–
Corps						
Line of the USAF	29,348 (88.8)	–	–	34,786 (87.7)	–	–
Non-line of the USAF	3,694 (11.2)	–	–	4,902 (12.3)	–	–
Rank Group						
E1 – E3	6,978 (21.1)	–	–	7,925 (19.9)	–	–
E4 – E6	15,811 (47.9)	–	–	20,742 (52.3)	–	–
E7 – E9	3,402 (10.3)	–	–	4,748 (11.9)	–	–
O1 – O3	4,259 (12.9)	–	–	3,543 (8.9)	–	–
O4 – O6	2,592 (7.8)	–	–	2,730 (3.9)	–	–

Table 4.9. Demographic & CR Fitness Characteristics Among Cases & Controls, 1999 – 2000

Covariate	Controls n (%)	Mean (±SD)	Range	Cases n (%)	Mean (±SD)	Range
Major Command	33,042			39,688		
ACC	9,144 (27.7)	–	–	10,136 (25.5)	–	–
AETC	4,907 (14.8)	–	–	6,300 (15.9)	–	–
AFMC	3,282 (9.9)	–	–	3,976 (10.0)	–	–
AFSOC	889 (2.7)	–	–	1,074 (2.7)	–	–
AFSPC	1,790 (5.4)	–	–	2,138 (5.4)	–	–
AMC	5,688 (17.2)	–	–	6,135 (15.5)	–	–
HQ/DRU/FOA/ OTHER	2,698 (8.2)	–	–	3,435 (8.7)	–	–
PACAF	2,490 (7.5)	–	–	3,613 (9.1)	–	–
USAFA	204 (0.6)	–	–	286 (0.7)	–	–
USAFE	1,950 (5.9)	–	–	2,595 (6.5)	–	–
Tobacco Use						
None	23,585 (71.4)	–	–	28,208 (71.1)	–	–
Cigarettes	7,173 (21.7)	–	–	8,602 (21.7)	–	–
Smokeless	1,396 (4.2)	–	–	1,643 (4.1)	–	–
Pipe/Cigar	424 (1.3)	–	–	575 (1.4)	–	–
All Types	464 (1.4)	–	–	660 (1.7)	–	–
Body Mass Index (kg/m^2)		25.2 (±3.4)	15.0 – 50.7		25.5 (±3.3)	15.1 – 50.0
Underweight (< 20)	1,859 (5.6)	–	–	1,755 (4.4)	–	–
Normal (20 – 24.99)	13,987 (42.3)	–	–	15,611 (39.3)	–	–
Overweight (25 – 29.99)	14,709 (44.5)	–	–	18,995 (47.9)	–	–
Obese (≥ 30)	2,487 (7.5)	–	–	3,327 (8.4)	–	–
VO_2 Max Values (ml/kg/min)		37.4 (±7.8)	15 – 80		37.7 (±7.9)	16 – 79
Pass	27,054 (81.9)	–	–	34,402 (86.7)	–	–
Fail	5,988 (18.1)	–	–	5,286 (13.3)	–	–

Table 4.10. Unintentional Nonfatal Injuries Among ADAF by Nature of Injury and Anatomic Location

Nature of Injury	Anatomic Location Injured: Ankle, foot, toe	Body part unspecified	Eye	Face, head, neck	Leg, pelvis	Knee	Arm, shoulder	Spinal column	Thorax, abdomen	Wrist, hand, finger	Total N (%)
TBI*	–	–	–	230	–	–	–	–	–	–	230 (0.6)
Superficial Injury	315	957	529	231	266	113	280	–	293	416	3,400 (8.6)
Burn	3	72	16	22	19	1	25	–	7	57	222 (0.6)
Traumatic Injury	30	15	2	–	3	2	27	–	2	44	125 (0.3)
RTD*	979	1,867	–	–	229	282	1,089	190	–	467	5,103 (12.4)
Effects of Environment	4	408	25	410	–	–	–	–	–	6	853 (2.2)
Foreign Body	20	–	283	56	2	–	2	–	39	20	422 (1.0)
Fracture	377	105	–	123	117	9	252	19	34	652	1,688 (4.3)
Wound	107	344	33	591	141	4	158	–	52	891	2,321 (5.6)
Joint Conditions	662	989	–	3	1,938	1,193	1,832	251	3	303	7,174 (18.1)
Lumbago, Backache	–	–	–	–	–	–	–	7,319	–	–	7,319 (18.4)
Sprain	1,992	2,551	–	24	173	1,212	813	1,965	215	751	9,696 (24.4)
Unspecified	–	305	18	63	239	–	222	2	68	219	1,136 (2.8)
Total N (%)	4,489 (11.3)	7,613 (19.1)	905 (2.3)	1,753 (4.4)	3,127 (7.9)	2,816 (7.1)	4,701 (11.8)	9,746 (24.6)	714 (1.8)	3,827 (9.6)	39,688 (100)

TBI: Traumatic Brain Injuries (e.g., concussion, coma, etc.); RTD: Repetitive Trauma Disorders (e.g., carpal tunnel syndrome, rotator cuff disorders, etc.)

Figure 4.1. Distribution of Anatomic Location of Injury by Gender Among ADAF, 2000

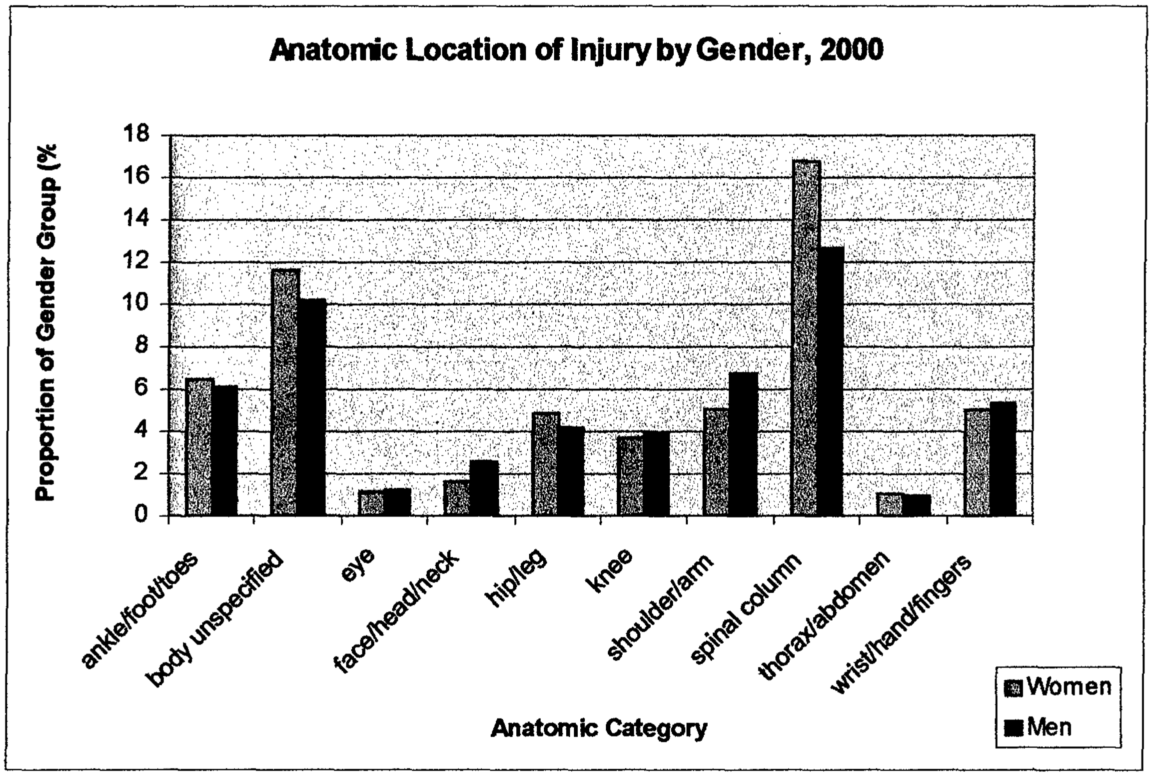


Figure 4.2. Distribution of Type of Injury by Gender Among ADAF, 2000

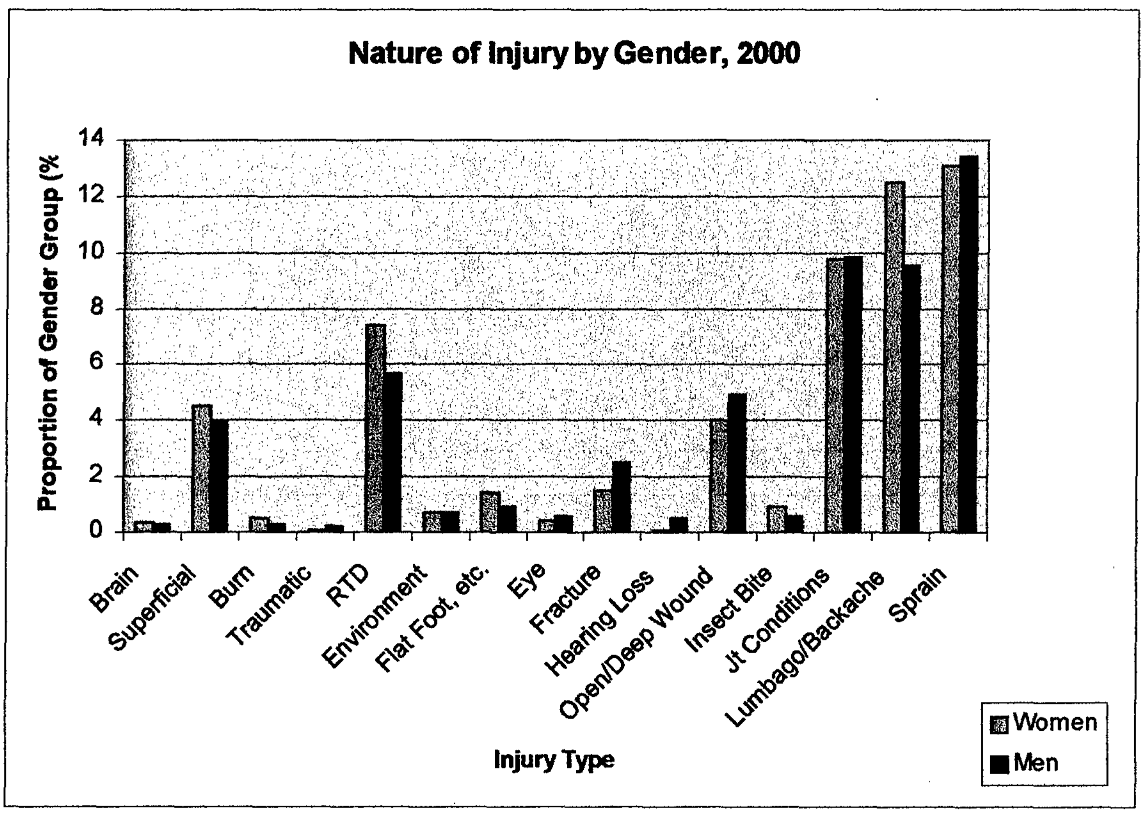


Figure 4.3. Distribution of Anatomic Location of Injury by Corps Among ADAF, 2000

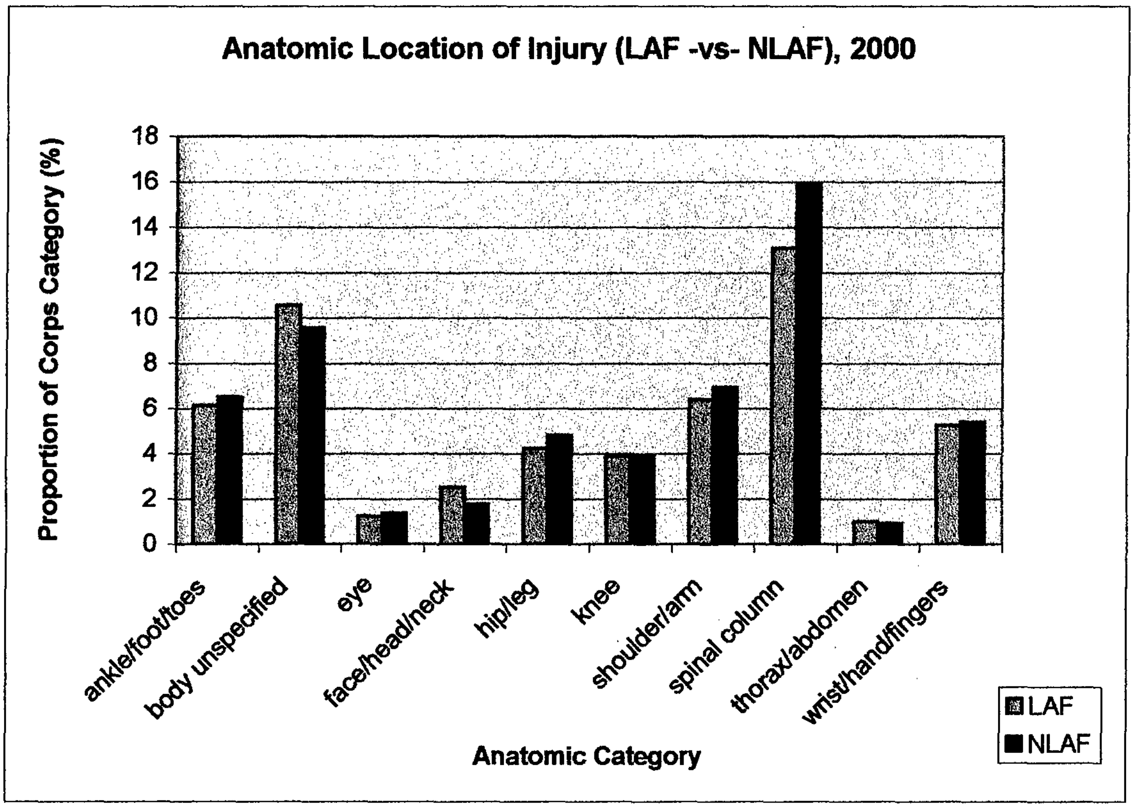


Figure 4.4. Distribution of Type of Injury by Corps Among ADAF, 2000

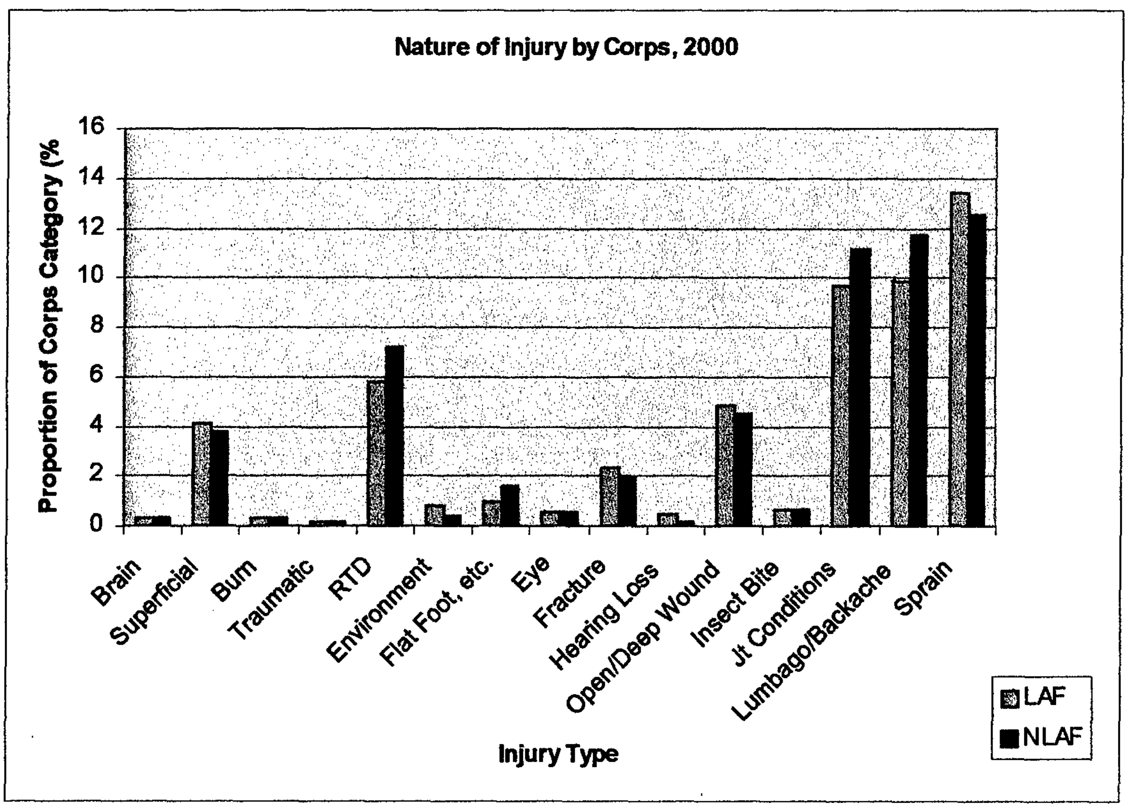


Figure 4.5. Distribution of Anatomic Location of Injury by Rank Group Among ADAF, 2000

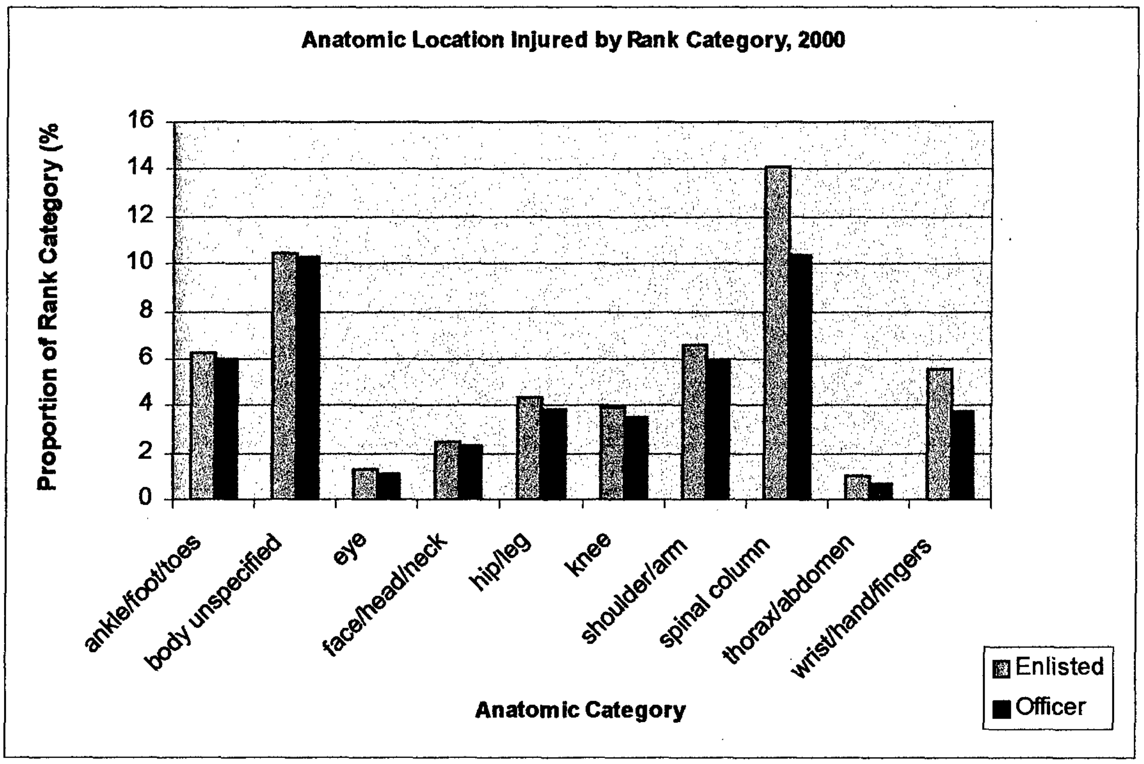
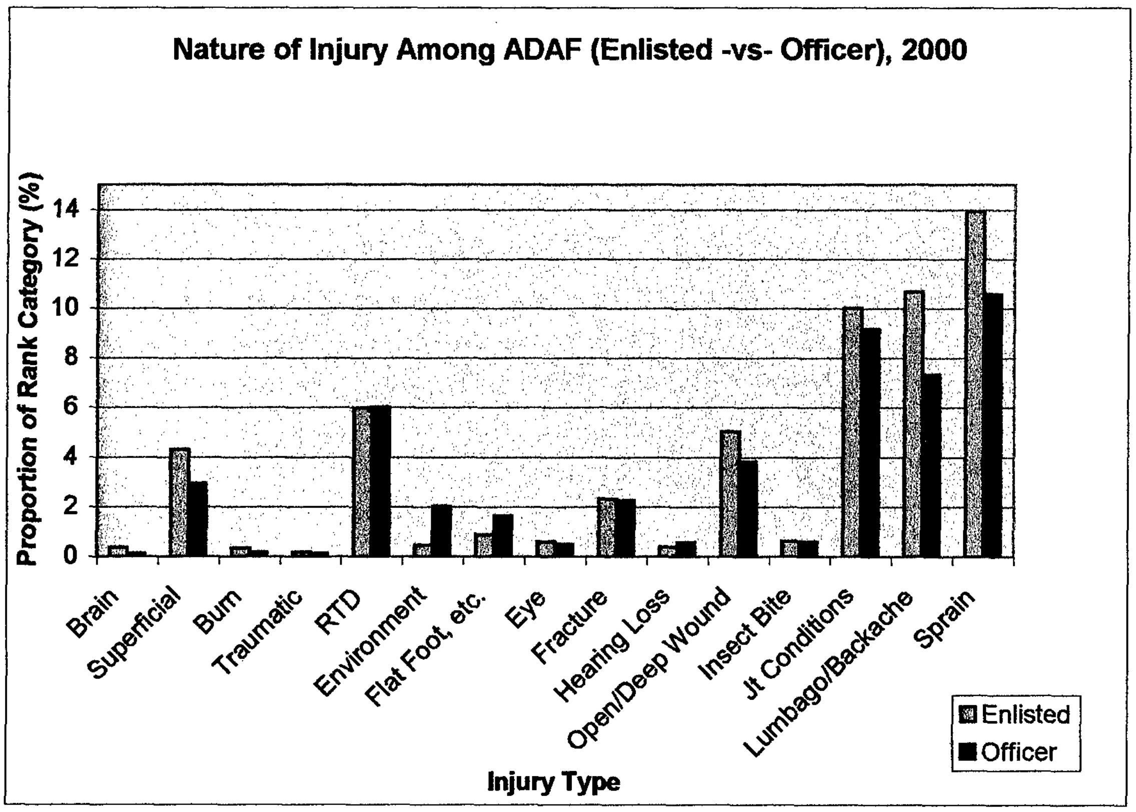


Figure 4.6 Distribution of Type of Injury by Rank Group Among ADAF, 2000



Bivariate Correlations

Results of the bivariate analysis are presented in Tables 4.11and 12. Comparing cases with controls, both groups were found to be predominantly male (80.6% among cases versus 82.5% among controls), white (70.2% among cases compared to 65.9% among controls), married (67.6% for cases versus 60.7% for controls), and had completed 1 – 4 years of college (67.7% for cases versus 71.1% for controls). Furthermore, the largest proportions of both groups belonged to the LAF (87.7% among cases versus 88.8% among controls), enlisted ranks (87.2% for cases versus 79.3% for controls), and were stationed at Air Force bases on the continental US (85% for cases versus 14% for controls). Proportionally, most of the cases and controls passed their annual cycle ergometry fitness evaluation (86.7% versus 81.9%, respectively), did not use tobacco products (71.1% versus 71.4%), but had a BMI value that would place them in the overweight or obese categories (56.3% for cases versus 52.0% for controls). In bivariate analysis of the distributions for the covariates, all were associated with highly significant p-values (all reached significance at the $p < 0.00$ levels), largely owing to this statistic's sensitivity to large sample sizes and the associated high power.

Table 4.11. Bivariate Analysis Among ADAF (Cases –vs- Controls), 1999 – 2000

Covariate	Cases (%)*	Controls (%)*	Chi-square (χ^2)	p-value
Age Groups (yrs)			261.15	0.000
17 – 20	3,529 (8.9)	3,448 (10.4)		
21 – 25	10,952 (27.6)	9,855 (29.8)		
26 – 30	7,225 (18.2)	6,726 (20.4)		
31 – 35	6,283 (15.8)	4,723 (14.3)		
36 – 40	7,625 (19.2)	5,309 (16.1)		
41 – 45	3,054 (7.7)	2,162 (6.5)		
46 – 50	821 (2.1)	658 (2.0)		
51+	199 (0.5)	161 (0.5)		
Gender			45.05	0.000
Male	31,973 (80.6)	27,261 (82.5)		
Female	7,715 (19.4)	5,781 (17.5)		
Race			688.45	0.000
White	27,871 (70.2)	21,777 (65.9)		
Black	6,247 (15.7)	4,701 (14.2)		
Hispanic	3,242 (8.2)	4,657 (14.1)		
Asian	1,130 (2.9)	1,076 (3.3)		
Am. Indian	328 (0.8)	201 (0.6)		
All Else	870 (2.2)	630 (1.9)		
Marital Status			343.73	0.000
Married	25,625 (67.6)	20,062 (60.7)		
Single	10,898 (27.5)	10,995 (33.3)		
All Else	3,165 (7.9)	1,985 (6.0)		
Education Level (Highest Attained)			1.60	0.000
High School/GED	4,762 (12.0)	1,344 (4.1)		
Some College	26,861 (67.7)	23,503 (71.1)		
Bachelor Degree	4,270 (10.7)	4,448 (13.4)		
Master Degree	3,092 (7.8)	2,827 (8.6)		
PhD/Professional Degree	703 (1.8)	920 (2.8)		
Corps			23.75	0.000
Line of the Air Force	34,786 (87.7)	29,348 (88.8)		
Non-line of the Air Force	4,902 (12.3)	3,694 (11.2)		
Rank Group			413.09	0.000
E1 – E3	7,925 (19.9)	6,978 (21.1)		
E4 – E6	20,742 (52.3)	15,811 (47.9)		
E7 – E9	4,748 (11.9)	3,402 (10.3)		
O1 – O3	3,543 (8.9)	4,259 (12.9)		
O4 – O6	2,730 (3.9)	2,592 (7.8)		

Table 4.12. Bivariate Analysis Among ADAF (Cases –vs- Controls), 1999 – 2000

Covariate	Cases (%)	Controls (%)	χ^2	p-value
	39,688	33,042		
Major Command			150.12	0.000
ACC	10,136 (25.5)	9,144 (27.7)		
AETC	6,300 (15.9)	4,907 (14.8)		
AFMC	3,976 (10.0)	3,282 (9.9)		
AFSOC	1,074 (2.7)	889 (2.7)		
AFSPC	2,138 (5.4)	1,790 (5.4)		
AMC	6,135 (15.5)	5,688 (17.2)		
HQ/DRU/FOA/OTHER	3,435 (8.7)	2,698 (8.2)		
PACAF	3,613 (9.1)	2,490 (7.5)		
USAFA	286 (0.7)	204 (0.6)		
USAFE	2,595 (6.5)	1,950 (5.9)		
Tobacco Use			11.96	0.018
None	28,208 (71.1)	23,585 (71.4)		
Cigarettes	8,602 (21.7)	7,173 (21.7)		
Smokeless	1,643 (4.1)	1,396 (4.2)		
Pipe/Cigar	575 (1.4)	424 (1.3)		
All Types	660 (1.7)	464 (1.4)		
Body Mass Index (kg/m^2)			152.46	0.000
Underweight (< 20)	1,755 (4.4)	1,859 (5.6)		
Normal Weight (20 – 24.99)	15,611 (39.3)	13,987 (42.3)		
Overweight (25 – 29.99)	18,995 (47.9)	14,709 (44.5)		
Obese (≥ 30)	3,327 (8.4)	2,487 (7.5)		
VO_2 Max Values (ml/kg/min)			314.99	0.000
Pass	34,402 (86.7)	27,054 (81.9)		
Fail	5,286 (13.3)	5,988 (18.1)		

Results of Hypothesis Testing for Research Questions

This section reports the results of statistical analyses performed to answer Research Questions 3 – 6. All questions were tested by fitting multiple logistic regression models to the data.

Multiple Regression Analysis

Assessment of Assumptions

Prior to formally testing the hypotheses, an assessment of the validity of assumptions for multiple regression was conducted. Plots of the studentized residuals versus the standardized predicted outcome values were examined to assess the distributional assumptions. No evidence of serious violations was found for the correct fit. The independence assumption was met after a review of the inclusion and exclusion criteria showed no pattern of repeated measures, non-random sampling, or contextual effects.

A case analysis revealed 630 observations with Pearson's residuals having larger than an absolute value of 3.0 (range: -3.25 – 3.71), suggesting that they may be outliers. However, these observations were not characterized as such since they did not clearly exhibit separation in the distribution of the residuals. Inspection of delta beta ($\Delta\beta$) indices showing the change in model coefficients if individual observations were dropped did not suggest excessive influence of any of the observations. A sensitivity study determining the impact of dropping the 630 outliers on all study results did not suggest any excessive influence of individual observations (results not shown). Therefore, they were not excluded from the regression models.

Structure of Covariates, and Interaction Terms

Continuously coded covariates (i.e., age, BMI and submaximal VO_2 values) were assessed for their linearity in the logit. Age, BMI and submaximal VO_2 values covariates were evaluated in separate regression models in their continuously coded state or coded categorically. All remaining nominal covariates were dummy coded in the models. Tests for interaction terms

showed that the ethnicity and tobacco use covariates demonstrated significant interaction; therefore the interaction term ("ethXtob") was included in the models (see Codebook in Appendix 1 for the interpretation of the coefficients by model). The use of variance inflation factors (VIFs) further assessed for the presence of collinearity between selected covariates and interaction terms yielded VIFs less than 10.

Likelihood Ratio Tests and Hosmer and Lemeshow's Goodness-of-Fit (χ^2 test)

Likelihood ratio tests were used to identify terms that were insignificant in the multiple logistic regression models, using a χ^2 probability value of 0.05 as a cutoff for model significance. However, terms – submaximal VO_2, tobacco use, and BMI – that were identified a priori for hypothesis tests were included in the regression models irrespective of their χ^2 probability value. The estimated logistic regression model coefficients (results are in Appendix 1, Tables XX) show that the overall relationships were statistically significant at the 0.05 levels except where noted. Point-estimation of the models' fit to the actual data was conducted using methods described by Hosmer and Lemeshow (2000). With the models shown in Tables 4-12 – 15, the Hosmer-Lemeshow tests for goodness of fit produced a fail to reject decision (i.e., all had large p-values). These results were consistent with the assumptions that the specified logistic models were adequate.

Overall Hypothesis

This hypothesis was derived from Research Question 3: Low CR fitness levels measured by low submaximal VO_2 and high BMI are associated with increased risk for unintentional injury-related morbidity among ADAF personnel. It tests the effects of the primary independent variables of interest, CR fitness – submaximal VO_2, tobacco use, and BMI – and covariates (e.g., age, gender, ethnicity, etc.) on the dependent variable, unintentional nonfatal injury outcome. Table 4.13 summarizes the results of the multiple regression analyses.

The unadjusted odds of an injury among ADAF personnel increased by a factor of 1.07 (1.06, 1.08) for an increase in five years increments; after controlling for all other covariates, the increase was a factor of 1.20 (1.18, 1.22) for an increase of five years. This gradient for an increase in the odds of an injury is easily noted when age was stratified by age groups (see Table 4.13). Women had greater odds for an injury than did men (adjusted OR 1.40; 95% CI: 1.34 – 1.47). Unadjusted and adjusted regression models yielded that Caucasians had a higher likelihood for an injury relative to non-white personnel except for American Indians (adjusted OR: 1.33; 95% CI: 1.09 –1.61). Interestingly, being single relative to being married was protective for injury (adjusted OR: 0.81; 95% CI: 0.78 – 0.84). In both adjusted and unadjusted models, as the level of education increased, the odds of injury decreased. Likewise, it was observed that with increasing rank, the likelihood of an injury decreased. After controlling for other covariates, active duty personnel belonging to the Non-line of the Air Force had 1.21 times higher odds of experiencing an injury relative to those who belonged to the Line of the Air Force.

The unadjusted odds of injury among ADAF personnel was 1.05 (1.04, 1.07) for every 10 ml/kg/min increase in submaximal VO_2 scores. The odds for injury was increased among those who passed their fitness tests by a factor of 1.44 (1.38, 1.49); therefore improving CR fitness was associated with increased likelihood of an injury among study participants. However, as BMI increased by five kg/m^2, the likelihood of an injury increased 1.15 times (1.12, 1.18). In unadjusted and adjusted models, the dichotomized variable for tobacco use did not demonstrate a statistically significant relationship between use and odds for an injury (OR: 1.01; 95% CI: 0.98 – 1.05). It did, however, when categorized by type of tobacco product used. Adjusting for all other covariates, the use of pipes and cigars or all combinations of tobacco products showed a statistically significant ($p < 0.05$) relationship between tobacco product used and the odds for an injury (OR: 1.18 and 1.27, respectively). The association of CR fitness with injury did not change in direction, but increased in magnitude of effect when adjustment for all covariates in the model. The odds of an injury for every 10-ml/kg/min increase in VO_2 max was 1.27 (1.25, 1.30). An increase in BMI by five kg/m^2 increased the odds for an injury by 20% (1.17, 1.24). A trend of increasing odds for injury was also observed when BMI was stratified by categories of increasing

BMI values (see Table 4.12). With these findings, high CR fitness levels (passing submaximal VO_2 scores and a BMI >20 kg/m^2) showed an increase in the odds for an unintentional nonfatal injury among study participants. Thus, the null is rejected with regard to increasing BMI, but we fail to reject the null with respect to submaximal VO_2 values.

Table 4.13. Probability of Injury Among ADAF: Unadjusted and Adjusted Odds Ratios and 95% Confidence Intervals

Active Duty Air Force Personnel**	Total Effect		Adjusted*	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Age (for a 5 year increase in years)* **	**1.07‡‡**	1.06 – 1.08	**1.20‡‡**	1.18 – 1.22
Age Groups (years)				
17 – 20 (reference group)	1.0	referent	1.0	referent
21 – 25	**1.06‡**	1.00 – 1.11	**1.13‡‡**	1.06 – 1.20
26 – 30	1.01	0.96 – 1.07	**1.16‡‡**	1.07 – 1.25
31 – 35	**1.26‡‡**	1.19 – 1.34	**1.43‡‡**	1.31 – 1.56
36 – 40	**1.36‡‡**	1.28 – 1.47	**1.69‡‡**	1.54 – 1.84
41 – 45	**1.31‡‡**	1.21 – 1.40	**1.86‡‡**	1.68 – 2.07
46 – 50	**1.16‡**	1.04 – 1.30	**1.97‡‡**	1.71 – 2.27
51+	1.13	0.91 – 1.39	**2.31‡‡**	1.82 – 2.92
Gender (Male –vs- Female)	**0.88‡‡**	0.85 – 0.91	**0.71‡‡**	0.68 – 0.75
Race				
White (reference)	1.0	referent	1.0	referent
Black	1.04	0.99 – 1.08	0.98	0.93 – 1.02
Hispanic	**0.54‡‡**	0.52 – 0.57	**0.53‡‡**	0.50 – 0.56
Asian	**0.82‡‡**	0.75 – 0.89	**0.89‡**	0.81 – 0.98
Am. Indian	**1.27‡**	1.07 – 1.52	**1.33‡**	1.09 – 1.61
All Else	1.08	0.97 – 1.19	**1.27‡‡**	1.13 – 1.42
Marital Status				
Married (reference)	1.0	referent	1.0	referent
Single	**0.78‡‡**	0.75 – 0.80	**0.81‡‡**	0.78 – 0.84
All Else	**1.25‡‡**	1.18 – 1.32	**1.15‡‡**	1.08 – 1.22
Education Level (Highest Attained)				
High School/GED (reference)	1.0	referent	1.0	referent
Some College	**0.32‡‡**	0.30 – 0.34	**0.30‡‡**	0.28 – 0.32
Bachelor Degree	**0.27‡‡**	0.25 – 0.29	**0.28‡‡**	0.26 – 0.31
Master Degree	**0.32‡‡**	0.28 – 0.33	**0.29‡‡**	0.26 – 0.33
PhD/Professional Degree	**0.21‡‡**	0.19 – 0.24	**0.18‡‡**	0.15 – 0.21
Corps (Non-line of the USAF –vs- Line)	**1.12‡‡**	1.07 – 1.17	**1.21‡‡**	1.15 – 1.27
Rank Group				
E1 – E3 (reference)	1.0	referent	1.0	referent
E4 – E6	**1.16‡‡**	1.11 – 1.20	**0.86‡‡**	0.82 – 0.91
E7 – E9	**1.23‡‡**	1.16 – 1.29	**0.75‡‡**	0.69 – 0.81
O1 – O3	**0.73‡‡**	0.69 – 0.77	**0.61‡‡**	0.55 – 0.67
O4 – O6	**0.93‡**	0.87 – 0.99	**0.56‡‡**	0.49 – 0.63
Tobacco Use (Yes –vs- No)	1.01	0.98 – 1.05	1.03	0.98 – 1.07
Tobacco Use				
None (reference)	1.0	referent	1.0	referent
Cigarettes	1.00	0.97 – 1.04	1.02	0.97 – 1.06
Smokeless	0.98	0.91 – 1.06	0.96	0.89 – 1.04
Pipe/Cigar	1.13	0.99 – 1.29	**1.18‡**	1.03 – 1.35
All Types	**1.19‡**	1.05 – 1.34	**1.27‡‡**	1.12 – 1.44
Body Mass Index (NIH BMI Categories)				
Normal Weight (20 – 25) (reference)	1.0	referent	1.0	referent
Underweight (≤ 20)	**0.85‡‡**	0.79 – 0.91	**0.82‡‡**	0.76 – 0.88
Overweight (≥ 26 – 30)	**1.16‡‡**	1.12 – 1.19	**1.18‡‡**	1.14 – 1.22
Obese (≥ 30)	**1.19‡‡**	1.13 – 1.27	**1.24‡‡**	1.16 – 1.31
BMI (5 unit increase in BMI kg/m^2)* **	**1.15‡‡**	1.12 – 1.18	**1.20‡‡**	1.17 – 1.24
VO_2 Max (10 unit increase in ml/kg/min)* **	**1.05‡‡**	1.04 – 1.07	**1.27‡‡**	1.25 – 1.30
Cycle Ergometry Result (Pass –vs- Fail)	**1.44‡‡**	1.38 – 1.49	**1.62‡‡**	1.55 – 1.68
EthnicXTobacco	**0.88‡‡**	0.86 – 0.90	**0.92‡‡**	0.89 – 0.95

*Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.000)

Sub-hypothesis #1

This hypothesis was derived from Research Question 4: High CR fitness levels (passing submaximal VO_2 scores and BMI <26) are associated with increased risk for injuries resulting from sports and recreational activities (e.g., basketball, softball, snowboarding, etc.). The comparison group (i.e., controls) was those who did not experience an injury. It tests the effects of the primary independent variables of interest, CR fitness – submaximal VO_2 and BMI – and covariates (e.g., age, gender, ethnicity, etc.) on unintentional nonfatal injury outcome. Table 4.14 summarizes the results of the multiple regression analyses.

Younger active duty personnel were at increased odds for an injury (unadjusted OR 0.84; 95% CI: 0.79 – 0.90), but after controlling for all other covariates, age was not significantly associated with the odds of an injury. Unadjusted and adjusted regression models yielded that Caucasians had higher likelihood for an injury relative to those of Hispanic descent, whereas American Indians were 1.7 times more likely than white active duty personnel to experience an injury from "sports and recreation" activities (adjusted OR: 1.69; 95% CI: 1.00 – 2.88). Men were 2.16 times more likely than women to experience an injury (1.57, 2.98). Marital status was not statistically significant for this type injury outcome. In both adjusted and unadjusted models, as the level of education increased, the odds of sports and recreationally acquired injuries decreased. Likewise, it was observed that with increasing rank, the likelihood of an injury decreased.

The unadjusted odds of injury among ADAF personnel was 1.49 (1.35, 1.65) for every 10 ml/kg/min increase in submaximal VO_2 scores. Among those who passed their fitness test, the odds for injury was 1.86 (1.38, 2.49); therefore improving CR fitness increased the likelihood of an injury among study participants. However, as BMI increased by five kg/m^2, the likelihood of an injury was 1.25 (1.10, 1.43). The association of CR fitness with injury did not change in direction, but increased in magnitude of effect when adjustment for all covariates in the model. The odds of an injury for every 10-ml/kg/min increase in VO_2 max was 1.61 (1.42, 1.82). An increase in BMI by five kg/m^2 yielded the odds for an injury of 1.20 (1.17, 1.24). While controlling for other variables, the "overweight" BMI category was the only category demonstrating statistical significance for the association of BMI on injury outcome (see Table 4.14). Active duty personnel

who passed their annual fitness evaluation were twice as likely to experience an injury than those who failed their cycle ergometry test, after controlling for other variables. With these findings, high CR fitness levels (passing submaximal VO_2 scores and increasing BMI in five kg/m^2 unit increments) showed an increase in the odds for a sports and recreational injury among study participants.

Table 4.14. Probability of Sports and Recreational Injuries Among ADAF: Unadjusted and Adjusted Odds Ratios and 95% Confidence Intervals

Active Duty Air Force Personnel**	Total Effect		Adjusted*	
	OR***	95% CI	OR***	95% CI
Age (for a 5 year increase in years)* **	**0.84‡‡**	0.79 – 0.90	1.03	0.92 – 1.14
Gender (Male –vs- Female)	**2.05‡‡**	1.5 – 2.8	**2.16‡‡**	1.57 – 2.98
Race				
White (reference)	1.0	referent	1.0	referent
Black	1.21	0.95 – 1.54	1.16	0.91 – 1.48
Hispanic	**0.49‡‡**	0.34 – 0.69	**0.50‡‡**	0.35 – 0.72
Asian	0.56	0.29 – 1.09	0.56	0.29 – 1.09
Am. Indian	1.59	0.95 – 2.69	**1.69‡**	1.00 – 2.88
All Else	0.67	0.16 – 2.69	0.61	0.15 – 2.48
Marital Status				
Married (reference)	1.0	referent	1.0	referent
Single	1.13	0.93 – 1.38	0.82	0.65 – 1.03
All Else	1.08	0.73 – 1.58	1.07	0.73 – 1.58
Education Level (Highest Attained)				
High School/GED (reference)	1.0	referent	1.0	referent
Some College	**0.31‡‡**	0.24 – 0.40	**0.32‡‡**	0.24 – 0.42
Bachelor Degree	**0.16‡‡**	0.11 – 0.25	**0.38‡‡**	0.22 – 0.66
Master Degree	**0.11‡‡**	0.06 – 0.19	**0.38‡**	0.18 – 0.90
PhD/Professional Degree	**0.07‡‡**	0.02 – 0.21	0.26	0.06 – 1.01
Rank Group				
E1 – E3 (reference)	1.0	referent	1.0	referent
E4 – E6	**0.80‡**	0.65 – 0.98	**0.72‡**	0.55 – 0.94
E7 – E9	**0.35‡‡**	0.23 – 0.54	**0.29‡‡**	0.17 – 0.52
O1 – O3	**0.26‡‡**	0.17 – 0.40	**0.21‡‡**	0.11 – 0.41
O4 – O6	**0.20‡‡**	0.11 – 0.37	**0.15‡‡**	0.06 – 0.41
BMI (NIH BMI Categories)				
Normal Weight (20 – 25) (reference)	1.0	referent	1.0	referent
Underweight (≤ 20)	0.64	0.38 – 1.10	0.61	0.36 – 1.04
Overweight (≥ 26 – 30)	**1.32‡**	1.09 – 1.61	**1.39‡‡**	1.14 – 1.22
Obese (≥ 30)	1.19	0.83 – 1.69	1.28	0.88 – 1.85
BMI (5 unit increase in kg/m^2)* **	**1.25‡‡**	1.10 – 1.43	**1.32‡‡**	1.15 – 1.53
Cycle Ergometry Result (Pass –vs- Fail)	**1.86‡‡**	1.38 – 2.49	**2.14‡‡**	1.58 – 2.89
VO_2 Max (10 unit increase in ml/kg/min)* **	**1.49‡‡**	1.35 – 1.65	**1.61‡‡**	1.42 – 1.82

*Adjusted for all other covariates; **n = 33,512; ***Continuously coded; ‡OR was statistically significant ($p < 0.05$); ‡‡OR was statistically significant ($p < 0.000$)

Sub-hypothesis #2

This hypothesis was derived from Research Question 5: Low CR fitness levels (measured by failing submaximal VO_2 scores and a BMI ≥30 kg/m^2) are associated with increased risk for "lumbago/backache" injuries (i.e., ICD-9-CM codes 724.2 and 724.5). It tests the effects of the primary independent variables of interest, CR fitness – submaximal VO_2, tobacco use, and BMI – and covariates (e.g., age, gender, ethnicity, etc.) on lumbago/backache injury. Table 4.15 summarizes the results of the multiple regression analyses.

In this model, as active duty personnel age, the odds for an injury increases (unadjusted OR 1.13; 95% CI: 1.11 – 1.15), and after controlling for all other covariates, age remains significantly associated with the odds of an injury (OR: 1.27; 95% CI: 1.24 – 1.31). Women were 1.41 times more likely than men to experience an injury (1.32, 1.49) and after adjustment, their odds for a lumbago or backache injury increased to 1.56 times that of men. American Indians and non-black, non-Hispanic, and non-Asians were more likely than Caucasians to experience a diagnosis of lumbago or backache (adjusted OR: 1.31 and 1.35, respectively). However, Caucasians were more likely to experience an injury relative to those of Hispanic descent. Being married (currently or previously) was not protective for this type injury outcome, whereas being single was associated with decreased odds of an injury (OR: 0.68; 95% CI: 0.64 – 0.74). In both adjusted and unadjusted models, the higher the level of education, the lower the odds of lumbago or backache injuries. Likewise, this was also found with increasing rank (see Table 4-14).

The unadjusted odds of injury among ADAF personnel was 0.89 (0.87, 0.93) for every 10 ml/kg/min increase in submaximal VO_2 scores, which meant that among active duty personnel with higher cycle ergometry scores, the odds for injury decreased. However, after adjusting for all other covariates in the model, odds for injury was 1.10 (1.00, 1.21); therefore improving CR fitness increased the likelihood of a back injury among study participants. Active duty personnel with a BMI ≥30 kg/m^2 increased the odds of an injury 1.10 times greater than active duty people with BMI <30 kg/m^2, in both models measuring the direct and indirect effects. Tobacco use showed a significant association ($p < 0.05$) with lumbago or backache injuries after controlling for other variables (OR: 1.07; 95% CI: 1.00 – 1.14). An increase in BMI by five kg/m^2 yielded the

odds for an injury of 1.20 (1.17, 1.24). With these findings, increasing submaximal VO_2 scores and having a BMI greater than or equal to 30 kg/m^2 showed an increase in the odds for lumbago or backache injuries among the Air Force active duty.

Table 4.15. Probability of Lumbago/Backache Injury Among ADAF: Unadjusted and Adjusted Odds Ratios and 95% Confidence Intervals

Active Duty Air Force Personnel**	Total Effect		Adjusted*	
	OR	95% CI	OR	95% CI
Age (for a 5 year increase in years)* **	**1.13‡‡**	1.11 – 1.15	**1.27‡‡**	1.24 – 1.31
Gender (Male –vs- Female)	**0.71‡‡**	0.67 – 0.76	**0.64‡‡**	0.59 – 0.69
Race				
White (reference)	1.0	referent	1.0	referent
Black	**1.10‡**	1.03 – 1.19	0.99	0.93 – 1.01
Hispanic	**0.61‡‡**	0.56 – 0.67	**0.57‡‡**	0.52 – 0.63
Asian	**0.84‡**	0.72 – 0.97	0.93	0.79 – 1.09
Am. Indian	1.29	0.97 – 1.73	**1.31‡‡**	0.96 – 1.79
All Else	1.09	0.92 – 1.31	**1.35‡**	1.12 – 1.64
Marital Status				
Married (reference)	1.0	referent	1.0	referent
Single	**0.63‡**	0.59 – 0.66	**0.68‡‡**	0.64 – 0.74
All Else	**1.22‡‡**	1.11 – 1.35	1.04	0.94 – 1.15
Education Level (Highest Attained)				
High School/GED (reference)	1.0	referent	1.0	referent
Some College	**0.35‡‡**	0.32 – 0.39	**0.30‡‡**	0.28 – 0.33
Bachelor Degree	**0.24‡‡**	0.22 – 0.27	**0.26‡‡**	0.22 – 0.29
Master Degree	**0.31‡‡**	0.27 – 0.35	**0.29‡‡**	0.12 – 0.21
PhD/Professional Degree	**0.20‡‡**	0.16 – 0.25	**0.16‡‡**	0.12– 0.21
Corps (Non-line of the USAF –vs- Line)	**1.27‡‡**	1.18 – 1.37	**1.34‡‡**	1.23 – 1.46
Rank Group				
E1 – E3 (reference)	1.0	referent	1.0	referent
E4 – E6	**1.28‡‡**	1.19 – 1.37	**0.85‡‡**	0.78 – 0.92
E7 – E9	**1.70‡‡**	1.56 – 1.86	**0.81‡**	0.71 – 0.93
O1 – O3	**0.59‡‡**	0.53 – 0.66	**0.46‡‡**	0.38 – 0.54
O4 – O6	0.96	0.85 – 1.07	**0.44‡‡**	0.35 – 0.56
Tobacco Use (Yes –vs- No)	1.04	0.99 – 1.11	**1.07‡**	1.00 – 1.14
BMI (≥30 kg/m^2 –vs- <30 kg/m^2)	**1.19‡‡**	1.10 – 1.30	**1.10‡**	1.00 – 1.21
VO_2 Max (10 unit increase in ml/kg/min)* **	**0.89‡‡**	0.87 – 0.93	**1.13‡‡**	1.09 – 1.17
EthnicXTobacco	**0.88‡‡**	0.84 – 0.92	**0.89‡‡**	0.84 – 0.95

*Adjusted for all other covariates; **n = 40,361; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.000)

Sub-hypothesis #3

This hypothesis was derived from Research Question 6: CR fitness levels are not associated with increased risk for noise-induced hearing loss. It tests the effects of the primary independent variables of interest, CR fitness – submaximal VO_2, tobacco use, and BMI – and covariates (e.g., age, gender, ethnicity, etc.) on noised-induced hearing loss injuries. Table 4.16 summarizes the results of the multiple regression analyses.

In this model, the odds for an injury increases as age increases (unadjusted OR 1.48; 95% CI: 1.39 – 1.58), and after controlling for all other covariates, increasing age remains significantly associated with the odds of hearing loss (OR: 1.68; 95% CI: 1.48 – 1.89). Men were 2.67 times more likely than women to experience an injury (1.47, 4.84) after adjusting for other covariates. Caucasians were four times more likely than African Americans and nearly 2.6 times more likely than Hispanics to experience noise-induced hearing loss injuries. The odds for this type injury outcome increased among married people compared to single ADAF personnel after adjusting for all other covariates. In both adjusted and unadjusted models, having a level of education higher than high school or equivalent decreased the odds of noise-induced hearing loss. In the adjusted model for rank groups comparing all categories to the most junior rank group (i.e., Airmen Basic to Airmen First Class), each rank category was associated with an increase in the odds for a hearing loss injury except among company grade officers (i.e., lieutenants and captains). Upon further examination, it was determined that these results were confounded by age (not shown). However, after adjusting for all other covariates, company grade officers had a statistically significant lower odds than the most junior enlisted personnel group for hearing loss injuries while there was no statistically significant relationship between the other rank groups and the odds of this type of injury (see Table 4.16). Line of the Air Force personnel were 2.78 times more likely than Non-line of the Air Force personnel to experience noise-induced hearing loss in both adjusted and unadjusted models.

The adjusted odds of injury among ADAF personnel was 1.43 (1.22, 1.67) for every 10 ml/kg/min increase in submaximal VO_2 scores, which meant that among active duty personnel with higher cycle ergometry scores, the odds for injury increased. The unadjusted odds of

hearing loss injuries increased 1.43 times for every increase by five kg/m^2, however after adjustment, there was no statistically significant relationship between increasing BMI and the odds for hearing loss. Tobacco use did not show a significant association with these types of injuries in models measuring both direct and indirect effects. With these findings, increasing submaximal VO_2 scores but not increasing BMI showed an increase in the odds for hearing loss among study subjects.

Table 4.16. Probability of Hearing Loss Injury Among ADAF: Unadjusted and Adjusted Odds Ratios and 95% Confidence Intervals

Active Duty Air Force Personnel**	Total Effect		Adjusted*	
	OR	95% CI	OR	95% CI
Age (for a 5 year increase in years)***	**1.48‡‡**	1.39 – 1.58	**1.68‡‡**	1.48 – 1.89
Gender (Male –vs- Female)	**5.37‡‡**	3.05 – 9.58	**2.67‡‡**	1.47 – 4.84
Race				
White (reference)	1.0	referent	1.0	referent
Black	**0.23‡‡**	0.13 – 0.40	**0.25‡‡**	0.14 – 0.43
Hispanic	**0.52‡**	0.35 – 0.76	**0.39‡‡**	0.27 – 0.59
Asian	0.47	0.21 – 1.05	0.58	0.26 – 1.31
Am. Indian	1.26	0.40 – 3.98	1.30	0.41 – 4.14
All Else	0.67	0.27 – 1.63	0.98	0.40 – 2.40
Marital Status				
Married (reference)	1.0	referent	1.0	referent
Single	**0.29‡‡**	0.21 – 0.41	**0.50‡**	0.34 – 0.74
All Else	0.67	0.41 – 1.09	0.69	0.42 – 1.15
Education Level (Highest Attained)				
High School/GED (reference)	1.0	referent	1.0	referent
Some College	**0.37‡‡**	0.25 – 0.54	**0.22‡‡**	0.15 – 0.33
Bachelor Degree	**0.31‡‡**	0.19 – 0.52	**0.19‡‡**	0.10 – 0.38
Master Degree	0.89	0.57 – 1.39	**0.19‡‡**	0.08 – 0.46
PhD/Professional Degree	**0.29‡**	0.12 – 0.71	**0.14‡**	0.04 – 0.48
Corps (Non-line of the USAF –vs- Line)	**0.31‡‡**	0.17 – 0.55	**0.36‡**	0.19 – 0.71
Rank Group				
E1 – E3 (reference)	1.0	referent	1.0	referent
E4 – E6	**2.03‡‡**	1.38 – 2.98	0.77	0.49 – 1.23
E7 – E9	**3.83‡‡**	2.49 – 5.89	0.64	0.35 – 1.18
O1 – O3	0.72	0.38 – 1.37	**0.33‡**	0.14 – 0.77
O4 – O6	**5.09‡**	3.31 – 7.84	0.73	0.29 – 1.81
Tobacco Use (Yes –vs- No)	1.19	0.94 – 1.51	1.27	0.98 – 1.63
BMI (5 unit increase in kg/m^2)***	**1.43‡‡**	1.22 – 1.67	1.19	0.98 – 1.44
VO_2 Max (10 unit increase in ml/kg/min)***	0.99	0.87 – 1.15	**1.43‡‡**	1.22 – 1.67

*Adjusted for all other covariates; **n = 32,916; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.000)

Additional Findings Using Polychotomous Logistic Regression Models

Introduction

Estimating the odds of multiple categories of injury using multinomial logit regression models in this study is an exploratory approach with these data. This section presents the results of two models, polychotomous categories for anatomic location of injury and type or nature of injury, adjusting for all covariates in the model. Regarding categories of body part injuries, multinomial logit regression models were fitted to the data with the outcome of interest divided into ten separate anatomic locations of injury categories that were then compared to the controls (i.e., no injury). In contrast, thirteen categories of the types of injury were created for the second polychotomous logistic regression. Both models used cardiorespiratory fitness variables, submaximal VO_2 scores and BMI, dichotomized into "pass –vs– fail" and "greater than or equal to 25 kg/m^2 –vs– less than 25 kg/m^2", respectively. Furthermore, no assumptions were made regarding the likelihood of injury outcomes; thus, no hypotheses were formally tested. The results reported herein refer to the indirect effects of the explanatory variables on the outcome of interest (Tables 4.17 – 20). The crude odds of an injury outcome among cases relative to controls are reported only if they differed substantially from adjusted odds (results not shown). All results of the likelihood of an injury among the Air Force active duty by any injury (i.e., anatomic location or type of injury) category are relative to uninjured personnel (i.e., controls).

Probability of Injury by Anatomic Location Category

Compared to controls the adjusted and unadjusted odds of an injury for all categories of anatomic location were higher among cases that passed the annual cycle ergometry evaluation versus those who failed. Having a BMI in excess of 25 kg/m^2 increased the likelihood of an injury for all body part categories except injuries involving the eye, head/face/neck, and thorax/abdomen categories, after controlling for other covariates. In the unadjusted model, BMI above 25 kg/m^2 was not significantly associated with an increase in injuries involving the wrist, hand or fingers. After adjusting for other covariates in the model, the odds for injuries involving

the hand, wrist or fingers reached statistical significance. Tobacco use was associated with an increase in the odds of injuries involving the face, head and neck category (OR: 1.12; 95% CI: 1.00-1.24). However, the odds of injuries in the unspecified anatomic location category was six percent higher among non-tobacco users than tobacco users. Otherwise, tobacco use was not found to have a statistically significantly association with injury by body part categories.

After adjusting for all other covariates in the model, age (increasing in five year increments) was associated with increased odds of an injury by any body part category, but did not reach statistical significance in eye, head/face/neck, and thorax/abdomen categories. However, the unadjusted odds of injury involving the head/face/neck category was nearly 10% higher among younger active duty personnel. After controlling for other covariates, the association between age and injury was not statistically significant. Males were at an increased likelihood for injuries involving the head/face/neck and arm/shoulder girdle categories (OR: 1.57 and 1.14, respectively) in both adjusted and unadjusted models. Conversely, females had greater odds of an injury involving the spinal column, leg/pelvic girdle, ankle/foot/toe, and unspecified body location categories (see Tables 4.17) before and after controlling for other covariates. In both unadjusted and adjusted models, Caucasians were nearly twice as likely as Hispanics to experience an injury across all injury categories. In contrast, African Americans had a 12% increased likelihood of injuries to the lower limb and pelvic girdle than did Caucasians. Interestingly, American Indians had statistically significant increased odds of experiencing injuries to the thorax/abdomen, face/head/neck, and unspecified body location categories with adjustment (OR: 2.08, 1.69, and 1.35, respectively) compared to Caucasians.

Unmarried people had an adjusted decreased likelihood for most injury by almost all body part categories relative to married or previously married personnel except injuries to the head/face/neck category. On the contrary, single women and men had a statistically significant increased odds for injuries involving the head/face/neck category (OR: 1.25; 95% CI: 1.13-1.38) in the unadjusted model. Across all anatomic location categories Air Force active duty with only a high school education or equivalent were more than twice as likely to experience an injury than active duty personnel with higher education levels. Most notably, personnel possessing a master

or higher degree were less nine to forty percent likely than an ADAF person with only a high school education to experience an injury to any body part. Personnel assigned to the Non-line of the Air Force (NLAF) were more likely to experience injuries in all categories except unspecified body, face/head/neck, and thorax/abdomen categories after controlling for all other covariates in the model. Generally, a trend of decreasing odds of an injury for all body part categories was observed as rank categories increased relative to the most junior enlisted category (Airman Basic to Airman First Class). In the unadjusted model, however, the direction of the effect was in the opposite direction and this was likely due to age confounding the relationship between rank and injury across most body part categories.

Probability of Injury by Nature of Injury Category

Across all types of injury categories in models that adjusted for and did not adjust for the effects of other covariates, passing the annual cycle ergometry exam was associated with an increased likelihood for an injury, but not all reached statistical significance (see Tables 4.18). An increased odds for all types of injuries among ADAF with a BMI value above 25 kg/m^2 was also observed in the adjusted model, and again, not all reached statistical significance. The use of tobacco products was associated with a statistically significant increase in odds for injuries in the "wound" category. Air Force personnel who claimed that they did not to use tobacco products were more likely to experience injuries found in the "repetitive trauma disorders", "foreign body", "joint conditions" and "sprains" categories after adjusting for all other covariates.

Regarding the polychotomous logistic regression model controlling for all covariates, age (increasing by five year increments) was associated with an increased risk for injuries found in the "repetitive trauma disorders", "joint conditions", "lumbago/backache", "sprains" and "unspecified" categories. However, younger personnel were found to have an increased likelihood for "traumatic brain injuries", and "burn" injury categories relative to older personnel in the model adjusting for the effects of the other covariates. Relative to women, men were at an increased odds for acute injuries in the "traumatic injury", "environmental effects", "fracture", and "wound" categories whereas women were more likely to experience injuries resulting from chronic or

repetitive insults (i.e., lumbago/backache, joint conditions and repetitive trauma disorders). However, women were 17% and 48%, respectively, more likely than men to have an injury of the acute nature such as, "superficial injury", and "burn" categories. ,Caucasian personnel were more than twice as likely than Hispanics to experience injuries in all types of injury categories in models adjusting for and not adjusting for the effects of the other independent variables. Active duty personnel within the ethnicity category of "all else" (i.e., non-White, non-Black, non-Hispanic, and non-Asian) were 23%, 31%, and 48% more likely than Caucasians to experience injuries in the "joint conditions", "lumbago/backache", "repetitive trauma disorders" and "unspecified" categories, respectively. Asians were less likely than Caucasians to experience injuries in the "repetitive trauma disorder", "fracture", "wound", "joint conditions" and "lumbago/backache" categories in the adjusted and unadjusted models. Relative to Caucasians, African Americans were 10% and 12%, respectively, more likely to experience injuries in the "sprains" and "traumatic injury" categories, but less likely to experience injuries in the "superficial injury", "repetitive trauma disorders", "environmental effects", "foreign body", "fracture", and "wounds" categories (OR: 0.53, 0.91, 0.46, 0.67, 0.76, and 0.82, respectively) in the adjusted model.

Currently or previously married Air Force personnel were more likely than unmarried personnel to experience an injury across all categories of injury type except for injuries in the "environmental effects" category, but that was not statistically significant in the model controlling for other covariates. However, in the polychotomous logistic regression model that did not adjust for the effects of other independent variables, single ADAF personnel were more likely than married personnel to experience injuries in the "traumatic brain injury", "superficial injury", and "wound" categories. Among ADAF personnel with a high school or equivalent diploma, they had a greater odds than personnel with higher level of education for an injury in all injury type categories in both adjusted and unadjusted models, although not all reached statistical significance. Compared to Line of the Air Force, Non-line of the Air Force personnel had an increased likelihood for an injury in all but "environmental effects" injury category in the model controlling for other independent variables. Generally, the most junior rank group had a higher odds relative to increasing senior rank groups for experiencing an injury by injury type category,

although not all reached statistical significance. However, relative to the most junior rank group (i.e., E1 – E3), officers were four times more likely to experience an injury in the "environmental effects" category in model adjusting for other covariates.

Table 4.17. Probability of Injury by Anatomic Location of Injury Among ADAF: Adjusted Odds Ratios and 95% Confidence Intervals

Covariates**	Indirect Effects for Anatomic Location Category									
	Ankle, foot, toe (RRR, 95% CI)		Body unspecified (RRR, 95% CI)		Eye (RRR, 95% CI)		Face, head, neck (RRR, 95% CI)		Leg, pelvis (RRR, 95% CI)	
Age (for a 5 year increase in years)*	**1.11**‡‡	1.08-1.15	**1.12**‡‡	1.09-1.16	1.08	0.99-1.16	1.00	0.94-1.06	**1.19**‡‡	1.15-1.24
Gender (Male –vs- Female)	**0.85**‡‡	0.78-0.92	**0.79**‡‡	0.74-0.85	1.03	0.86-1.25	**1.57**‡‡	1.35-1.84	**0.76**‡‡	0.69-0.84
Race										
White (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Black	1.08	0.99-1.18	1.04	0.97-1.12	0.83	0.68-1.01	**0.76**‡	0.66-0.89	**1.12**‡	1.01-1.24
Hispanic	**0.57**‡‡	0.51-0.63	**0.54**‡‡	0.46-0.55	**0.48**‡‡	0.37-0.61	**0.43**‡	0.35-0.52	**0.51**‡	0.44-0.58
Asian	0.84	0.69-1.02	0.92	0.79-1.06	0.77	0.51-1.15	0.77	0.57-1.03	**0.62**‡	0.48-0.79
Am. Indian	1.23	0.87-1.75	**1.35**‡	1.03-1.78	1.22	0.60-2.49	**1.69**‡	1.07-2.67	0.86	0.54-1.39
All Else	1.22	0.98-1.51	1.17	0.99-1.39	1.43	0.96-2.13	1.19	0.87-1.63	1.24	0.97-1.59
Marital Status										
Married (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Single	**0.91**‡	0.84-0.98	**0.86**‡‡	0.91-0.92	**0.77**‡	0.65-0.92	1.06	0.94-1.19	**0.83**‡‡	0.75-0.92
All Else	**1.16**‡	1.03-1.31	**1.24**‡‡	1.12-1.36	1.14	0.88-1.48	1.20	098-1.48	1.01	0.87-1.17
Education Level (Highest Attained)										
High School/GED (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Some College	**0.30**‡‡	0.27-0.34	**0.36**‡‡	0.33-0.39	**0.29**‡‡	0.24-0.37	**0.26**‡‡	0.22-0.30	**0.30**‡‡	0.27-0.34
Bachelor Degree	**0.31**‡‡	0.25-0.37	**0.35**‡‡	0.30-0.40	**0.26**‡‡	0.18-0.39	**0.27**‡‡	0.19-0.36	**0.29**‡‡	0.24-0.37
Master Degree	**0.35**‡‡	0.27-0.45	**0.32**‡‡	0.26-0.39	**0.24**‡‡	0.14-0.42	**0.20**‡‡	0.13-0.30	**0.39**‡‡	0.29-0.51
PhD/Professional Degree	**0.25**‡‡	0.18-0.35	**0.19**‡‡	0.14-0.25	**0.23**‡‡	0.12-0.45	**0.09**‡‡	0.05-0.18	**0.20**‡‡	0.14-0.29
Corps (Non-line of the USAF –vs- Line)	**1.17**‡	1.05-1.30	0.99	0.91-1.08	**1.31**‡	1.06-1.64	1.03	0.85-1.23	**1.26**‡‡	1.12-1.42
Rank Group										
E1 – E3 (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
E4 – E6	**0.87**‡	0.79-0.97	**0.89**‡	0.82-0.97	**0.75**‡	0.61-0.93	**0.82**‡	0.71-0.94	0.93	0.82-1.05
E7 – E9	**0.63**‡‡	0.53-0.75	**0.76**‡‡	0.67-0.88	**0.64**‡	0.44-0.92	**0.75**‡	0.56-0.99	**0.81**‡	0.67-0.99
O1 – O3	**0.66**‡‡	0.53-0.80	**0.83**‡	0.71-0.97	**0.63**‡	0.40-0.98	0.75	0.54-1.04	**0.59**‡‡	0.47-0.76
O4 – O6	**0.58**‡‡	0.44-0.76	**0.69**‡‡	0.56-0.86	0.61	0.34-1.11	1.18	0.76-1.84	**0.49**‡‡	0.36-0.67
Tobacco Use (Yes –vs- No)	0.94	0.88-1.01	**0.94**‡	0.87-0.97	0.91	0.78-1.06	**1.12**‡	1.00-1.24	0.99	0.91-1.08
BMI (≥25 kg/m^2 –vs– <25 kg/m^2)	**1.36**‡‡	1.27-1.45	**1.19**‡‡	1.13-1.26	1.13	0.98-1.31	1.09	0.99-1.21	**1.26**‡‡	1.16-1.36
Cycle Ergometry Result (Pass –vs- Fail)	**1.58**‡‡	1.44-1.73	**1.66**‡‡	1.54-1.80	**1.40**‡	1.16-1.70	**1.83**‡‡	1.56-2.14	**1.66**‡‡	1.49-1.85

***Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant ($p < 0.05$); ‡‡OR was statistically significant ($p < 0.005$)**

Table 4.17. Probability of Injury by Anatomic Location of Injury Among ADAF: Adjusted Odds Ratios and 95% Confidence Intervals

Covariates**	Indirect Effects for Anatomic Location Category									
	Knee (RRR, 95% CI)		Arm, shoulder (RRR, 95% CI)		Spinal Column (RRR, 95% CI)		Thorax, abdomen (RRR, 95% CI)		Wrist, hand, finger (RRR, 95% CI)	
Age (for a 5 year increase in years)***	**1.12‡‡**	1.07-1.17	**1.29‡‡**	1.26-1.34	**1.23‡‡**	1.19-1.36	1.08	0.99-1.17	**1.08‡‡**	1.04-1.12
Gender (Male –vs- Female)	0.92	0.82-1.03	**1.14‡**	1.04-1.25	**0.66‡‡**	0.62-0.69	0.89	0.73-1.09	1.06	0.96-1.16
Race										
White (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Black	1.04	0.93-1.16	**0.83‡‡**	0.75-0.91	0.95	0.89-1.02	**0.78‡**	1.00-1.03	**0.89‡**	0.80-0.98
Hispanic	**0.50‡‡**	0.43-0.58	**0.53‡‡**	0.48-0.59	**0.51‡‡**	0.47-0.56	**0.45‡‡**	0.34-0.61	**0.45‡‡**	0.42-0.54
Asian	**0.72‡**	0.56-0.92	**0.77‡**	0.63-0.93	0.88	0.77-1.01	0.94	0.62-1.43	0.82	0.68-1.01
Am. Indian	0.91	0.56-1.48	0.98	0.67-1.42	1.08	0.83-1.41	**2.08‡**	1.12-3.85	1.15	0.79-1.68
All Else	1.00	0.75-1.33	1.02	0.81-1.28	1.14	0.97-1.34	1.14	0.69-1.89	1.22	0.97-1.52
Marital Status										
Married (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Single	**0.77‡‡**	0.69-0.85	**0.84‡‡**	0.77-0.92	**0.71‡‡**	0.67-0.76	**0.70‡‡**	0.58-0.86	**0.84‡‡**	0.77-0.92
All Else	1.11	0.96-1.29	**1.18‡**	1.05-1.32	**1.12‡**	1.02-1.22	1.09	0.81-1.45	**1.18‡**	1.03-1.35
Education Level (Highest Attained)										
High School/GED (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Some College	**0.34‡‡**	0.29-0.38	**0.27‡‡**	0.25-0.31	**0.30‡‡**	0.28-0.33	**0.28‡‡**	0.22-0.35	**0.26‡‡**	0.23-0.29
Bachelor Degree	**0.41‡‡**	0.33-0.51	**0.23‡‡**	0.19-0.28	**0.27‡‡**	0.23-0.31	**0.23‡‡**	0.15-0.37	**0.24‡‡**	0.19-0.29
Master Degree	**0.37‡‡**	0.27-0.50	**0.26‡‡**	0.21-0.33	**0.29‡‡**	0.24-0.35	**0.28‡‡**	0.15-0.51	**0.24‡‡**	0.18-0.32
PhD/Professional Degree	**0.29‡‡**	0.19-0.43	**0.14‡‡**	0.10-0.19	**0.17‡‡**	0.13-0.22	**0.19‡‡**	0.08-0.44	**0.21‡‡**	0.14-0.30
Corps (Non-line of the USAF –vs- Line)	**1.15‡**	1.01-1.31	**1.33‡‡**	1.20-1.47	**1.32‡‡**	1.22-1.42	1.09	0.85-1.42	**1.27‡‡**	1.13-1.42
Rank Group										
E1 – E3 (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
E4 – E6	0.97	0.86-1.10	0.98	0.88-1.09	**0.83‡‡**	0.77-0.89	0.86	0.68-1.09	**0.81‡‡**	0.73-0.90
E7 – E9	**0.79‡**	0.64-0.98	**0.84‡**	0.71-0.99	**0.78‡‡**	0.69-0.88	0.75	0.49-1.12	**0.64‡‡**	0.53-0.78
O1 – O3	**0.54‡‡**	0.42-0.69	**0.66‡‡**	0.54-0.81	**0.49‡‡**	0.42-0.56	**0.52‡**	0.31-0.88	**0.56‡‡**	0.45-0.70
O4 – O6	**0.60‡**	0.43-0.83	**0.59‡‡**	0.46-0.78	**0.47‡‡**	0.38-0.57	0.53	0.27-1.07	**0.38‡‡**	0.28-0.53
Tobacco Use (Yes –vs- No)	0.94	0.86-1.03	0.94	0.87-1.01	0.99	0.95-1.05	1.04	0.88-1.23	0.97	0.89-1.05
BMI (≥25 kg/m^2 –vs– <25 kg/m^2)	**1.32‡‡**	1.21-1.43	**1.24‡‡**	1.16-1.33	**1.17‡‡**	1.11-1.23	1.00	0.86-1.18	**1.09‡**	1.02-1.18
Cycle Ergometry Result (Pass –vs- Fail)	**1.61‡‡**	1.44-1.81	**1.67‡‡**	1.53-1.83	**1.50‡‡**	1.40-1.60	**1.73‡‡**	1.37-2.19	**1.74‡‡**	1.57-1.93

*Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant ($p < 0.05$); ‡‡OR was statistically significant ($p < 0.005$)

Table 4.18. Probability of Injury by Type of Injury Among ADAF: Adjusted Odds Ratios and 95% Confidence Intervals

Covariates**	Indirect Effects for Nature of Injury Category									
	TBI (RRR, 95% CI)		Superficial Injury (RRR, 95% CI)		Burn (RRR, 95% CI)		Traumatic Injury (RRR, 95% CI)		RTD (RRR, 95% CI)	
Age (for a 5 year increase in years)* **	**0.75‡**	0.62-0.89	0.99	0.95-1.04	**0.79‡**	0.67-0.94	1.17	0.97-1.42	**1.40‡‡**	1.36-1.45
Gender (Male –vs- Female)	1.02	0.72-1.45	**0.83‡‡**	0.75-0.91	**0.52‡‡**	0.38-0.72	**1.99‡**	1.06-3.75	**0.58‡‡**	0.54-0.63
Race										
White (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Black	0.69	0.46-1.04	**0.89‡**	0.80-0.99	0.68	0.44-1.03	1.12	0.69-1.84	**0.91‡**	0.84-0.99
Hispanic	**0.31‡‡**	0.17-0.58	**0.53‡‡**	0.47-0.60	**0.38‡‡**	0.21-0.66	0.58	0.31-1.09	**0.53‡‡**	0.48-0.58
Asian	0.80	0.37-1.71	0.99	0.81-1.20	0.47	0.17-1.28	1.29	0.52-3.20	**0.78‡‡**	0.65-0.94
Am. Indian	2.24	0.82-6.11	1.26	0.86-1.85	2.76	1.12-6.83	–	–	1.14	0.81-1.61
All Else	1.73	0.88-3.40	1.12	0.88-1.43	1.38	0.65-2.97	1.87	0.68-5.14	**1.31‡‡**	1.07-1.61
Marital Status										
Married (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Single	0.96	0.69-1.31	**0.83‡‡**	0.76-0.91	**0.64‡**	0.47-0.87	**0.59‡**	0.35-0.98	**0.78‡‡**	0.72-0.85
All Else	**2.25‡‡**	1.40-3.59	**1.19‡**	1.03-1.37	1.05	0.61-1.81	**2.21‡‡**	1.30-3.77	**1.16‡**	1.04-1.29
Education Level (Highest Attained)										
High School/GED (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Some College	**0.24‡‡**	0.17-0.34	**0.29‡‡**	0.26-0.33	**0.34‡‡**	0.23-0.50	**0.28‡‡**	0.15-0.44	**0.34‡‡**	0.30-0.38
Bachelor Degree	**0.16‡‡**	0.05-0.51	**0.33‡‡**	0.24-0.37	**0.24‡**	0.08-0.72	**0.33‡**	0.13-0.83	**0.32‡‡**	0.27-0.37
Master Degree	**0.09‡‡**	0.02-0.49	**0.33‡‡**	0.25-0.45	**0.22‡**	0.05-0.97	0.38	0.10-1.43	**0.35‡‡**	0.28-0.44
PhD/Professional Degree	**0.09‡**	0.01-0.71	**0.17‡‡**	0.11-0.27	0.25	0.04-1.47	0.10	0.01-1.12	**0.22‡‡**	0.16-0.29
Corps (Non-line of the USAF –vs- Line)	1.28	0.82-2.00	1.11	0.99-1.26	1.09	0.71-1.69	1.14	0.61-2.15	**1.25‡‡**	1.14-1.37
Rank Group										
E1 – E3 (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
E4 – E6	**0.69‡**	0.48-0.99	**0.79‡‡**	0.71-0.88	0.94	0.65-1.36	0.70	0.39-1.26	0.96	0.86-1.07
E7 – E9	0.59	0.23-1.51	**0.66‡‡**	0.54-0.80	**0.20‡**	0.06-0.73	0.41	0.16-1.06	**0.80‡‡**	0.68-0.94
O1 – O3	0.55	0.16-1.87	**0.57‡‡**	0.48-0.72	0.78	0.24-2.56	0.32	0.10-1.01	**0.65‡‡**	0.53-0.78
O4 – O6	1.34	0.25-7.28	**0.48‡‡**	0.35-0.67	0.76	0.15-3.81	0.32	0.07-1.42	**0.56‡‡**	0.44-0.71
Tobacco Use (Yes –vs- No)	1.15	0.87-1.52	1.06	0.98-1.15	1.14	0.85-1.51	0.87	0.58-1.32	**0.83‡‡**	0.77-0.89
BMI (≥25 kg/m^2 –vs– <25 kg/m^2)	1.28	0.97-1.69	**1.09‡**	1.01-1.07	**1.34‡**	1.01-1.79	1.25	0.85-1.84	**1.31‡‡**	1.22-1.40
Cycle Ergometry Result (Pass –vs- Fail)	1.49	0.98-2.26	**1.73‡‡**	1.54-1.93	1.25	0.84-1.86	1.26	0.78-2.02	**1.63‡‡**	1.50-1.78

***Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.005)**

Table 4.18. Probability of Injury by Type of Injury Among ADAF: Adjusted Odds Ratios and 95% Confidence Intervals

Covariatesl**	Indirect Effects for Nature of Injury Category									
	Environmental (RRR, 95% CI)		Foreign Body (RRR, 95% CI)		Fracture (RRR, 95% CI)		Wound (RRR, 95% CI)		Joint Conditions (RRR, 95% CI)	
Age (for a 5 year increase in years)* **	1.01	0.93-1.10	1.11	0.99-1.23	1.05	0.99-1.11	0.98	0.94-1.04	**1.26‡‡**	1.22-1.30
Gender (Male –vs- Female)	**1.25‡**	1.01-1.56	1.16	0.86-1.55	**1.63‡‡**	1.31-1.91	**1.46‡‡**	1.29-1.67	**0.85‡‡**	0.79-0.91
Race										
White (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Black	**0.46‡‡**	0.35-0.61	**0.67‡**	0.49-0.91	**0.76‡‡**	0.65-0.89	**0.82‡‡**	0.72-0.93	1.05	0.97-1.13
Hispanic	**0.46‡‡**	0.35-0.59	**0.36‡‡**	0.24-0.53	**0.45‡‡**	0.38-0.55	**0.45‡‡**	0.38-0.53	**0.52‡‡**	0.48-0.57
Asian	0.79	0.53-1.19	0.64	0.34-1.21	**0.69‡**	0.50-0.94	**0.77‡**	0.59-0.99	**0.76‡‡**	0.64-0.89
Am. Indian	1.19	0.56-2.55	1.88	0.83-4.27	1.33	0.79-2.22	1.38	0.89-2.14	1.19	0.89-1.61
All Else	0.92	0.59-1.46	1.16	0.61-2.19	0.82	0.56-1.19	0.95	0.74-1.34	**1.23‡**	1.03-1.48
Marital Status										
Married (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Single	1.03	0.87-1.22	**0.71‡**	0.55-.092	0.91	0.80-1.03	0.98	0.88-1.09	**0.80‡‡**	0.74-0.86
All Else	0.83	0.59-1.16	0.83	0.54-1.27	**1.53‡‡**	1.27-1.83	**1.25‡**	1.05-1.48	**1.10‡**	1.00-1.22
Education Level (Highest Attained)										
High School/GED (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
Some College	**0.40‡‡**	0.30-0.53	**0.34‡‡**	0.25-0.47	**0.29‡‡**	0.26-0.35	**0.30‡‡**	0.26-0.34	**0.29‡‡**	0.27-0.32
Bachelor Degree	**0.42‡‡**	0.27-0.66	**0.27‡‡**	0.15-0.49	**0.26‡‡**	0.18-0.35	**0.31‡‡**	0.24-0.40	**0.28‡‡**	0.24-0.33
Master Degree	**0.17‡‡**	0.10-0.30	**0.19‡‡**	0.08-0.46	**0.23‡‡**	0.15-0.35	**0.31‡‡**	0.22-0.45	**0.34‡‡**	0.28-0.41
PhD/Professional Degree	**0.10‡‡**	0.04-0.23	**0.19‡‡**	0.07-0.53	**0.23‡‡**	0.14-0.38	**0.23‡‡**	0.14-0.37	**0.19‡‡**	0.15-0.26
Corps (Non-line of the USAF –vs- Line)	**0.50‡‡**	0.36-0.69	1.19	0.85-1.66	1.06	0.89-1.27	**1.23‡**	1.06-1.43	**1.30‡‡**	1.19-1.42
Rank Group										
E1 – E3 (reference)	1.00	–	1.00	–	1.00	–	1.00	–	1.00	–
E4 – E6	1.18	0.92-1.16	0.89	0.65-1.21	0.88	0.76-1.02	**0.82‡‡**	0.72-0.93	0.96	0.88-1.05
E7 – E9	**1.68‡**	1.13-2.51	0.63	0.37-1.06	**0.57‡**	0.43-0.76	**0.73‡**	0.58-0.94	**0.83‡**	0.73-0.96
O1 – O3	**4.16‡‡**	2.67-6.46	0.66	0.34-1.30	0.84	0.59-1.19	**0.61‡‡**	0.46-0.81	**0.59‡‡**	0.51-0.71
O4 – O6	**4.15‡‡**	2.34-7.46	0.77	0.32-1.86	0.91	0.58-1.43	**0.53‡‡**	0.36-0.79	**0.52‡‡**	0.42-0.65
Tobacco Use (Yes –vs- No)	1.04	0.88-1.23	**0.78‡**	0.62-0.97	1.04	0.93-1.16	**1.11‡**	1.01-1.22	**0.91‡‡**	0.86-0.97
BMI (≥25 kg/m² –vs– <25 kg/m²)	1.05	0.91-1.22	**1.31‡**	1.06-1.62	1.01	0.91-1.13	1.07	0.97-1.07	**1.29‡‡**	1.22-1.37
Cycle Ergometry Result (Pass –vs- Fail)	**1.96‡‡**	1.55-2.45	1.26	0.97-1.65	**1.46‡‡**	1.26-1.69	**2.01‡‡**	1.74-2.31	**1.64‡‡**	1.52-1.77

***Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.005)**

Table 4.18. Probability of Injury by Type of Injury Among ADAF: Adjusted Odds Ratios and 95% Confidence Intervals

Covariates**	Indirect Effects for Nature of Injury Category					
	Lumbago/Backache (RRR, 95% CI)		Sprain (RRR, 95% CI)		Unspecified (RRR, 95% CI)	
Age (for a 5 year increase in years)* **	**1.24‡‡**	1.20-1.27	**1.08‡‡**	1.05-1.10	**1.08‡**	1.01-1.15
Gender (Male –vs- Female)	**0.65‡‡**	0.61-0.70	0.95	0.89-1.01	0.98	0.79-1.09
Race						
White (reference)	1.00	–	1.00	–	1.00	–
Black	0.99	0.92-1.06	**1.10‡‡**	1.04-1.18	0.88	0.73-1.05
Hispanic	**0.54‡‡**	0.49-0.59	**0.49‡‡**	0.45-0.53	**0.51‡‡**	0.41-0.64
Asian	**0.84‡**	0.72-0.98	0.89	0.78-1.01	0.90	0.64-1.27
Am. Indian	1.14	0.85-1.53	0.97	0.74-1.29	0.98	0.48-2.00
All Else	**1.23‡**	1.03-1.48	1.07	0.91-1.26	**1.48‡**	1.03-2.12
Marital Status						
Married (reference)	1.00	–	1.00	–	1.00	–
Single	**0.70‡‡**	0.66-0.76	**0.84‡‡**	0.79-0.89	**0.83‡**	0.71-0.97
All Else	1.05	0.95-1.16	**1.18‡‡**	1.08-1.29	1.14	0.90-1.45
Education Level (Highest Attained)						
High School/GED (reference)	1.00	–	1.00	–	1.00	–
Some College	**0.32‡‡**	0.29-0.35	**0.29‡‡**	0.27-0.32	**0.26‡‡**	0.22-031
Bachelor Degree	**0.27‡‡**	0.23-0.32	**0.29‡‡**	0.25-0.33	**0.22‡‡**	0.15-0.32
Master Degree	**0.30‡‡**	0.25-0.37	**0.30‡‡**	0.25-0.37	**0.21‡‡**	0.13-0.34
PhD/Professional Degree	**0.17‡‡**	0.13-0.23	**0.19‡‡**	0.15-0.25	**0.16‡‡**	0.08-0.30
Corps (Non-line of the USAF –vs- Line)	**1.32‡‡**	1.21-1.43	**1.11‡**	1.03-1.21	1.21	0.99-1.48
Rank Group						
E1 – E3 (reference)	1.00	–	1.00	–	1.00	–
E4 – E6	**0.83‡‡**	0.76-0.90	**0.92‡**	0.85-0.98	**0.82‡**	0.69-0.99
E7 – E9	**0.81‡‡**	0.71-0.92	**0.70‡‡**	0.62-0.79	**0.66‡**	0.47-0.92
O1 – O3	**0.46‡‡**	0.39-0.55	**0.61‡‡**	0.53-0.71	0.67	0.44-1.00
O4 – O6	**0.45‡‡**	0.36-0.56	**0.54‡‡**	0.44-0.66	0.67	0.39-1.16
Tobacco Use (Yes –vs- No)	1.02	0.96-1.08	**0.95‡**	0.90-1.00	1.04	0.91-1.19
BMI (≥25 kg/m^2 –vs- <25 kg/m^2)	**1.17‡‡**	1.10-1.24	**1.26‡‡**	1.20-1.33	1.10	0.97-1.25
Cycle Ergometry Result (Pass –vs- Fail)	**1.47‡‡**	1.36-1.58	**1.65‡‡**	1.54-1.76	**1.56‡‡**	1.29-1.86

***Adjusted for all other covariates; **n = 72,730; ***Continuously coded; ‡OR was statistically significant (p <0.05); ‡‡OR was statistically significant (p <0.005)**

Table 4.19. Observed Variances and Covariances by Anatomic Location of Injury Category

Body Part Category	Chi-Square (χ^2) Test that all coefficients are zero (χ^2, p-value)									
	1	2	3	4	5	6	7	8	9	10
Ankle/Foot/Toe (1)	866.15 <0.0000									
Body Part Unspecified (2)	60.61 <0.0000	1107.01 <0.0000								
Eye (3)	**26.47** **0.189**	41.87 0.0044	225.66 <0.0000							
Face/Head/Neck (4)	187.79 <0.0000	227.52 <0.0000	66.46 <0.0000	615.78 <0.0000						
Lower Limb/Pelvic Girdle (5)	66.56 <0.0000	90.28 <0.0000	55.37 <0.0001	277.07 <0.0000	813.33 <0.0000					
Knee (6)	44.66 0.0019	62.99 <0.0000	36.89 0.0173	212.23 <0.0000	34.48 0.0322	606.54 <0.0000				
Upper Limb/Shoulder Girdle (7)	246.99 <0.0000	331.44 <0.0000	96.11 <0.0000	353.79 <0.0000	117.73 <0.0000	108.22 <0.0000	1459.31 <0.0000			
Spinal Column (8)	248.73 <0.0000	308.56 <0.0000	82.44 <0.0000	457.68 <0.0000	67.45 <0.0000	118.91 <0.0000	215.20 <0.0000	2278.12 <0.0000		
Thorax/Abdomen (9)	46.61 0.0011	44.41 <0.0021	**16.94** **0.7146**	67.03 <0.0000	55.90 0.0001	47.05 0.0009	90.32 <0.0000	56.40 <0.0000	245.39 <0.0000	
Wrist/Hand/Finger (10)	109.85 <0.0000	167.74 <0.0000	**19.98** **0.5225**	114.26 <0.0000	171.51 <0.0000	126.56 <0.0000	327.65 <0.0000	332.97 <0.0000	**20.28** **0.5033**	1083.79 <0.0000

NOTE: Covariances in bold are indicative of possible violation of the multivariate normality assumption

Table 4.20. Observed Variances and Covariances by Type of Injury Category

Type of Injury Category	Chi-Square (χ^2) Test that all coefficients are zero (χ^2, p-value)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
TBI (1)	195.8 <0.000												
Superficial Injury (2)	53.63 0.0001	875.6 <0.000											
Burn (3)	26.82 0.1768	41.94 0.0043	130.4 <0.000										
Traumatic Injury (4)	56.88 <0.000	35.84 0.0228	56.88 <0.000	64.61 <0.000									
RTD (5)	212.97 <0.000	773.87 <0.000	131.09 <0.000	37.66 0.0141	1815.85 <0.000								
Environmental (6)	157.48 <0.000	422.13 <0.000	146.69 <0.000	78.93 <0.000	635.17 <0.000	440.5 <0.000							
Foreign Body (7)	80.77 <0.000	65.18 <0.000	57.32 <0.000	**20.99** **0.4595**	93.07 <0.000	137.84 <0.000	125.93 <0.000						
Fracture (8)	74.45 <0.000	116.22 <0.000	84.92 <0.000	**24.77** **0.2571**	516.94 <0.000	258.98 <0.000	39.11 0.0095	449.62 <0.000					
Wound (9)	51.91 0.0002	75.26 <0.000	72.28 <0.000	38.27 0.0120	798.91 <0.000	327.95 <0.000	65.07 <0.000	50.54 0.0003	692.2 <0.000				
Joint Conditions (10)	157.15 <0.000	503.2 <0.000	106.13 <0.000	**22.71** **0.3594**	154.23 <0.000	610.79 <0.000	48.00 0.0007	302.79 <0.000	501.21 <0.000	1836.6 <0.000			
Lumbago/ Backache (11)	138.54 <0.000	407.42 <0.000	78.77 <0.000	**27.45** **0.1566**	247.84 <0.000	733.22 <0.000	56.60 <0.000	342.60 <0.000	506.05 <0.000	133.88 <0.000	1840.3 <0.000		
Sprain (12)	92.03 <0.000	130.49 <0.000	70.13 <0.000	**22.01** **0.3990**	806.59 <0.000	544.67 <0.000	36.01 0.0218	127.28 <0.000	173.88 <0.000	377.85 <0.000	420.61 <0.000	1746.0 <0.000	
Unspecified (13)	61.84 <0.000	**23.61** **0.3124**	50.31 0.0003	**24.20** **0.2837**	264.47 <0.000	253.80 <0.000	**30.63** **0.0801**	50.47 0.0003	52.42 0.0002	129.13 <0.000	111.32 <0.000	**26.20** **0.1989**	344.57 <0.000

NOTE: Covariances in bold are indicative of possible violation of the multivariate normality assumption

CHAPTER 5. DISCUSSION

Introduction

This study examined cardiorespiratory fitness (CR fitness) risk factors that were hypothesized to be associated with unintentional nonfatal injuries among Air Force active duty personnel. A case-control study design was used to explore the relationship between CR fitness and unintentional nonfatal injuries among selected injured and non-injured USAF personnel in 1999 and 2000 (n = 72,730). Results from both multiple logistic regression and polychotomous logistic regression modeling statistical analyses yielded strong support for positive associations between CR fitness (submaximal VO_2 scores) and injuries. The findings provided mixed support for the association of high BMI and injuries, and negligible support for the relationship of tobacco use and injuries.

This chapter interprets the results of the study in relation to existing empirical literature on unintentional nonfatal injuries and the literature that provided the conceptual framework for the study. The chapter first discusses the sources of data used in this study. Second, research hypotheses that were empirically supported are discussed. Additionally, it explores alternative explanations for those hypotheses that may refute extant research findings. Third, strengths and limitations of the study and their possible impact are identified, accompanied by a discussion of methods through which the study could have been improved. The chapter concludes with a discussion of the implications for Air Force policy and by forwarding suggestions for future research with respect to substantive inquiry and methods relevant to this topic.

Data Sources

Mining administrative and healthcare data for epidemiological purposes is not uncommon in military research since the military systematically collects data on its personnel on a routine basis. One of the distinguishing characteristics of this study is that the data used in this study was an amalgamation of five different data sources: ambulatory and inpatient medical information

from the Defense Medical Surveillance System, Ground and Industrial Mishap reports from the Air Force Safety Center, annual fitness data from the Air Force Fitness Program Support Database, and USAF personnel data taken from the Defense Manpower Data Center. Quantifying the association between unintentional nonfatal injury and cardiorespiratory fitness among active duty servicemembers was only possible through the linkages of these data sources.

Of note, records of medical encounters were relatively complete, however reportable mishaps (e.g., injuries that result in at least one lost duty day) were not. Furthermore, the E-code fields from the inpatient database were nonexistent, and STANAG codes were too few to be of value in the statistical analysis. Determining the rationale for omissions of required information from safety center reports and inpatient hospitalizations deserves appropriate attention from the safety and medical communities. Despite these limitations and those of case-control designs, researchers with these same data sources could readily employ retrospective cohort, nested designs or longitudinal data analysis to address issues of how, if at all, CR fitness is causally related to injuries.

Descriptive Statistical Findings

This part of the study preceded the hypothesis testing and was intended to compare cases to controls according to their socio-demographic distributions as well as their CR fitness factors. Notably, Caucasians in this study were under-represented while Hispanics were over-represented relative to the USAF population. This finding could be a result of an increased compliance with medical exams and standards instructions by Hispanics relative to Caucasians, thereby introducing a form of selection bias in this study. Statistically significant differences were found in the bivariate analyses (Pearson's χ^2 test, $p < 0.05$) comparing cases to controls across various strata (e.g., age groups, marital status, ethnic group, etc.). These findings were likely due to selection criteria for cases and controls as well as the relatively large sample size.

Injuries among cases were enumerated according to the body part injured and nature of the injury, and stratified according to the demographic data. Injuries to the extremities

represented nearly half of all injuries while injuries to the spinal column represented almost twenty-five percent of injuries by anatomic location. Other studies have shown that lower extremity injuries (i.e., knee and ankle) account for the largest proportion of acute nonfatal injuries by body part (Lauder et al., 2000; Jones et al., 2002; Billings CE, 2004). Nearly 18% of all injuries were diagnosed as lumbago or backache (ICD-9-CM 724.2 & 724.5, respectively) while sprains and injuries involving joints accounted for almost 43% of the total injuries in this study. These findings support the findings from numerous studies within military and civilian populations (Jones BH, 1983; Jordaan and Schwellnus, 1994; Krentz et al, 1997; Amoroso et al., 1997; Smith et al., 2000; Billings CE, 2004).

Hypothesis Testing

The overall research hypothesis and subordinate sub-hypotheses 2 – 3 were not supported when tested with these data. Overall high submaximal VO_2 (above the age and gender required scores for passing the annual cycle ergometry fitness evaluation) and high BMI values (above 25 kg/m^2) were associated with an increased likelihood of unintentional nonfatal injury based on multiple logistic regression analysis. Using combinations of tobacco products (e.g., cigarettes, pipes, cigars, and smokeless) or only smoking pipes and cigars increased the likelihood for all injuries, however statistical significance was not achieved with any other tobacco product category in multiple logistic regression. It may be that only one year of data collection for injuries is an insufficient amount of time to examine the possible correlation of tobacco use with injuries. It could also be a form of selection bias where more tobacco using individuals were injured before his/her annual cycle ergometry fitness evaluation, and would have been excluded from this study. Also, individuals were excluded if they had an "invalid" cycle ergometry test result, and it could be that more tobacco users had invalid fitness test results than did non-tobacco users.

The clear gradient of increasing odds of experiencing an injury as BMI values increase supports findings from previous studies (Macera et al., 1989; Jones et al., 1993; Hootman et al., 2002; Billings CE, 2004). This study also supports the findings from other studies where women

were at an increased likelihood of injury relative to men (Deuster PA, Jones BH, Moore J, 1997; Bell et al., 2000; Knapik et al., 2001). Additionally, this study showed decreasing odds for injury as rank increased, as have been demonstrated in literature (Lauder et al., 2000; Knapik et al., 2002).

Several studies with military training populations have shown that Caucasians experience injuries at greater rates than African Americans or Hispanics (Gardner et al., 1988; Jones et al., 1993). The results from the hypothesis test clearly support these earlier findings. It has been suggested that African Americans have denser bones and therefore, may explain the higher incidence of stress fractures among Caucasians (Jones et al., 1993; Nelson et al., 1995; Finkelstein et al., 2002). Accounting for the decreased likelihood of injuries among Hispanics relative to Caucasians needs clarification.

Interestingly, this study found a protective effect against injuries with increasing levels of education and is most likely highly correlated with status (i.e., rank) and age. In a study of injuries among US Army trainees, Knapik et al. found that married personnel were at an increased risk for injuries relative to single soldiers but offered no explanation for the observed outcome (Knapik et al., 2003). Within this study, being married or previously married was associated with an increased risk for injuries and it is possible that risk taking behaviors are not diminished by marriage. Finally, this study found a positive association for injuries among personnel assigned to the medical, legal, and chaplain professions (i.e., Non-line of the Air Force [NLAF]). While studies of civilian populations have shown that medical personnel have an increased risk for occupational injuries, it is unclear why personnel assigned to the NLAF than Line of the Air Force had a greater likelihood for injury (Garg and Moore, 1992; Conway H and Svenson J, 1998; Bejia et al., 2005).

Sub-hypothesis 1

Research sub-hypothesis 1, injuries resulting from sports and recreational activity are associated with high cardiorespiratory fitness, was supported when tested with multiple logistic regression analysis. This is consistent with findings documented in the literature where individuals who are

more fit are more likely to participate in activities that would put them at greater risk for experiencing an injury (Hootman et al., 1996; Jones et al., 1997; Lauder et al., 2000). Furthermore, active duty men in this study were twice as likely as women to experience an injury resulting from exposure to sports and recreational activities. Regarding why a protective effect exists for sports and recreational injuries among Hispanics relative to Caucasians may be a function of social and cultural differences in medical seeking behaviors. It may be that Hispanics are less inclined than Caucasians to seek medical care for less severe injuries sustained during sports and recreational activities (i.e., injuries that do not require hospitalization or lost duty time).

Sub-hypothesis 2

High cardiorespiratory fitness (VO_2 max) was not expected to be associated with injuries resulting from chronic physiological insult to the musculoskeletal region of the spinal column as these injuries have been found to be associated with a sedentary lifestyle (Garg A and Moore JS; 1992; Burdorf A, Naaktgeboren B, de Groot HC, 1993; Hildebrandt VH, Bongers PM, Dul J, Van Dijk FJH, Kemper HCG, 2000). However, an increased likelihood for such injuries was expected to be associated with higher body mass indices (i.e., above 25 kg/m^2) as has been found in empirical literature (Jones BH and Knapik JJ, 1999; Robbins et al., 2002). Unlike findings from studies where cigarette smoking was associated with increased risk for musculoskeletal injuries, an association between tobacco use and injuries was not found with multiple logistic regression analysis in this study (Reynolds et al, 1994; Lincoln et al., 2003). In this study, women were found to have a greater likelihood than men for lumbago and backache injuries and support the findings from other studies conducted in military training environments and civilian occupational settings (Pope MH, 1989; Duester et al., 1997; Bejia et al., 2005).

Several reasons may explain these findings. First, the Air Force encourages and expects its personnel to participate in regular physical activities and it creates opportunities for individuals to engage in physical fitness behaviors (e.g., USAF sponsored extramural sports: basketball, flag football, softball, etc.). Second, by regulation, the Air Force permits its personnel to maintain body weight and therefore, BMI values that would place them in the "overweight" category despite

not having a corresponding high percentage of body fat. Additionally, it is not unusual to find active duty individuals who were "overfat" according to USAF weight standards, but have passing VO_2 max values. Third, since the Air Force leadership discourages tobacco use, personnel may feel compelled to deny using tobacco products when asked during the cycle ergometry fitness evaluation. Fourth, healthcare services are free to the active duty force and therefore, individuals may be more inclined to seek medical attention for injuries. Taken in toto, study participants who were overweight or obese (according to body mass indices) may have been exercising regularly, and have placed sufficient biomechanical stress on their lumbar region to cause enough physical pain to warrant a medical visit.

Sub-hypothesis 3

It was not anticipated that noise-induced hearing loss (NIHL) injuries would be related to cardiorespiratory fitness but after adjustment, high VO_2 max values (10 unit increase in ml/kg/min) were found to be independently associated with an increased likelihood for noise-induced injury. Male active duty personnel were nearly 2.7 times more likely than women and servicemembers assigned to the Line of the Air Force had 2.8 times the odds compared to Non-line personnel to be diagnosed with this type of injury. While distinguishing between occupational and recreational exposure to noise (above 85 dB) was not possible with these data, the relationship of high VO_2 max values with an increased likelihood of NIHL injuries remains unclear. Given the Air Force's adherence to the laws and regulations for protecting the health and safety of its workers, it may be that a lack of compliance with the use of hearing protection devices outside the occupational setting in noisy environments explains some of these results. Additionally, the military is exempt from Occupational Safety and Health Administration's (OSHA) regulations when carrying out wartime missions, and OSHA regulations do not apply to the US military stationed on many overseas installations, so reinforcement of hearing protection policies could be substantially diminished. It is possible that as active duty personnel near retirement or separation from military service, they are more likely to report having a hearing loss injury, or to be found with this type of injury as part of their medical out-processing requirements.

Additional Findings (Polychotomous Logistic Regression)

Body Part Injured

Cases who passed the cycle ergometry fitness evaluation had an increased odds for all injuries, and while statistical significance was not achieved for all categories, having a BMI in excess of 25 kg/m^2 was also associated with an increase in the odds for injuries. This finding supports the overall hypothesis tested, and clearly overweight or obese personnel may be at an increased risk for injuries to certain body parts (e.g., ankle, knee, spinal column, etc.) given the increased biomechanical stress placed on joints during any physical activity. This study showed that men were 57% more likely than women to experience injuries to the face, head or neck, but without data regarding exposure to an activity (e.g., boxing, horseplay, etc.), this finding cannot be explained with these data, alone. While tobacco use was positively associated with injuries to the head, face and neck, this is an inexplicable finding without more data regarding dose (i.e., frequency of tobacco product used, length of time using the product, and amount used) and exposure to an activity. In other studies of musculoskeletal injuries in military populations, the relationship of cigarette smoking with increased risk for injuries has been demonstrated (Reynolds et al., 1994; Altarac et al., 2000; Lincoln et al., 2003).

Types of Injury

Compared to controls, passing the fitness test showed a positive association among cases when stratified by nature of injury in polychotomous logistic regression, although not all achieved statistical significance. As was observed in the overall hypothesis test, cases with a BMI exceeding 25 kg/m^2 had a higher likelihood for an injury when categorized by type. Cases who were non-tobacco users were at increased odds for "repetitive trauma", "foreign body", "joint conditions" and "sprains" types of injuries, whereas cases that used tobacco products had an increased odds for "wound" injuries. Without exposure to activity data, history of tobacco use and dose, and prior history of injuries, these findings are inconclusive. The odds of "environmental"

injuries categories was four times higher in officers compared to the most junior enlisted, and is largely due to the high numbers of hearing loss injuries reported in officers. Active duty males were more likely to experience traumatic injuries, "environmental", fractures, and wounds, whereas females were more likely to experience superficial injuries, burns, repetitive trauma injuries, joint conditions and lumbago/backache. Several studies in military and civilian populations show similar results when examining gender differences for acute versus chronic injuries (Garg and Moore, 1992; Jones et al., 1993; Deuster et al., 1997; Bell et al., 2000; Lauder et al., 2000; Snedecor et al., 2000; Hootman et al., 2002).

Study Strengths and Limitations

Limitations

Case-control designs have several limitations that apply to this study. First, it was impossible to control for exposure to or involvement in activities during which injuries occur (e.g., sports and recreation). Injuries that were recorded in the AFSAS have relatively complete data in the "activity" fields whereas data from the controls did not have any such information. In this manner, controls may not have had the same opportunity for exposures to activities as the cases. While the exposure of interest is CR fitness level, those individuals with low CR fitness may have reduced opportunity for participation in injury-producing activities. Conversely, individuals with high CR fitness levels may be more likely to participate in such activities. Therefore, estimates of increased risk for injury among airmen with high or low CR fitness levels are, at best, conservative. Second, associations between exposures and outcomes do not imply that a causal relationship exists. While this study showed that increasing submaximal VO_2 values were associated with higher odds of injury outcomes, it should not be interpreted to mean that passing scores for the fitness test results in an injury in the USAF active duty population. While it's logical to assume that servicemembers who were more fit were more likely to engage in physical activities that, in turn, placed them at risk for an injury, this study does not definitively demonstrate that relationship. Third, proper sampling of cases and controls is problematic in

case-control study designs and is a threat to the validity of the study. This study minimized selection bias of controls by including individuals that did not have a medical visit for an injury in 1999, and must have had a physical examination within the same year of the cycle ergometry fitness evaluation. Controls who went on to experience an injury in 2000 became the cases in this study, thereby further reducing selection bias.

Issues with measurement are not exclusive to case-control studies and this study was limited to utilizing a case definition for an injury provided by the Army Medical Surveillance Activity (AMSA). This definition included ICD-9-CM diagnosis for medical conditions that may not be considered an injury by some experts (e.g., glaucoma, chorioretinal scars, etc.). Also, case ascertainment for incident injuries was relatively straightforward from a conceptual perspective; however, differentiating sudden-onset injuries from those resulting from repeated exposures to trauma were less precise. For instance, an overweight or obese individual who eventually sustained an acute injury such as a lumbar sprain or herniated intervertebral disc may be diagnosed with an acute injury but could have experienced undiagnosed lumbago prior to the acute injury. Furthermore, individuals who may have sustained an injury prior to the study's start date (January 1, 1999) and were injured during the study period may be unlike individuals who experienced an injury for the first time.

Numerous unmeasured, unobserved variables were not evaluated with this study and may have influenced both CR fitness levels and injury among ADAF personnel. These unobserved variables included – but were not limited to – the following: the distal economic and political factors, cultural and socio-behavioral factors, stress, nutritional status, sleep, frequency and duration of deployments, and occupational structural influences (i.e., sedentary vs. active occupations stratified by rank and attendant responsibilities – type/amount of work-related tasks, personnel, matériel resources, etc.). The length of the study period (one year) may be insufficient in identifying how components of CR fitness levels (i.e., submaximal $\dot{V}O_2$ and BMI) influenced the probability of injury over time. It was expected that weight loss or gain might change CR fitness level and in turn, influence injury outcomes; however, this study's results may be inconclusive regarding the extent to which such changes can be detected. Finally, this study was limited to

describing the experience of those active duty USAF personnel selected for inclusion. It may not be generalizable to the Air Force active duty population that was excluded, other military populations or civilians.

Strengths

The choice of variables in this study presented a singular opportunity to reveal the associations of specific CR fitness risk factors with injuries that have not been previously explored in studies conducted with military populations. This study combined CR fitness data with data for injuries for each airman using his/her unique identifiers (i.e., name, social security number and date of birth). In so doing, tracking the natural history of an airman's initial treatment for an incident injury and its consequent outcomes (e.g., lost duty time, or length of stay in hospital) relative to his/her CR fitness was possible. The various databases selected contain relatively complete data, thereby, offered excellent follow-up with minimal loss of subjects within the source cohort.

In addition to the strengths previously discussed in the above sections, this study was the first of its kind to examine the relationship between CR fitness levels and injury-related morbidity among ADAF personnel. Case-control designs are by nature one of the most expedient (relative to exhaustive retrospective cohort studies or randomized controlled trials) available to researchers since they are more affordable in terms of economic cost and resources required (Kelsey et al., 1996). While access to a complete array of predictors for traumatic injuries was impossible, this study utilized existing high quality data in its analyses by applying specific inclusion and exclusion criteria for cases and controls. Injury data recorded in the AFSAS database may be the best information available for the nature of reportable injuries among ADAF personnel. Despite its limitations with respect to missing data for injury severity and activity, it remains the sole source for certain exposure variables of interest.

Given the nature of the research aims and hypotheses, and available data sources, the descriptive and explanatory case-control designs and statistical analyses were sufficiently sophisticated in their attempt to answer the research questions. The master dataset represented

the first time independent and dependent variables of interest were examined using a case-control study design on the Air Force active duty population. Finally, this provides a reasonable foundation for future studies to explore the risk factors for injuries among military populations, and may be used to inform additional studies of the burden of these injuries.

Implications for Policy and Research

The purpose of this study was to describe and explain the relationship between cardiorespiratory fitness and injuries among ADAF personnel. Directions for future research involve improving on the study design, refining measurement and analysis using the same data sources that were employed in this study. Another related direction must consider the role military policy has on physical fitness with respect to injury prevention and control.

Measurement

Supplementing the primary independent variables, submaximal VO_2 and BMI, with additional measures of fitness requires further consideration for future studies. Physical activity (i.e., mode or type of exercise, intensity, duration and frequency) has been shown to be related to weight loss, increased risk for injuries and therefore, by including measures of physical activity in future studies would permit researchers to address two issues of measurement, potential confounding and exposure to activity (Jones BH, 1983; Jones et al., 1994; Krentz et al., 1997; Stofan et al., 1998; Jones and Knapik, 1999; Popovich et al., 2000; Knapik et al., 2001; Hootman et al., 2001; Weir et al., 2001). The Air Force began collecting physical activity data on its members during the administration of the annual fitness examination in 2001 and therefore, the fitness program database provides a source for these measures that could be used in future studies.

Several studies have demonstrated that tobacco use is associated with increased risk for musculoskeletal injuries so incorporating specific measures of tobacco use (i.e., type, amount and frequency of use, and history of use) is an important measure for future studies (Blake and Parker, 1991; Reynolds et al., 1994; Altarac et al., 2000; Lincoln et al., 2003). In addition to

questions about tobacco use and the type of product used, active duty members were queried about the amount and frequency of tobacco product used beginning in 2001. While data regarding prior history of tobacco use was not collected during annual fitness evaluations, data on current tobacco use does exist and should be exploited to address how tobacco use may interact or confound the relationship of CR fitness to injury outcomes in future studies.

Air Force members who exceed maximum body fat standards are placed in the Weight Management Program, and are monitored on a monthly basis. They are required to lose one percent of their total weight (or 3 lbs for women and 5 lbs for men) each month until they reach their maximum allowable weight (AFI 40-502, 2002, p. 42). Records of the monthly weigh-in and Gulick tape measurements are maintained in a separate database, which could be used to identify individuals enrolled in the Weight Management Program, and obtain data for their body fat percentage (a more accurate measure of fat free mass than BMI). While these individuals may have passed the annual cycle ergometry fitness evaluation, they are also encouraged to exercise more frequently and vigorously as part of the weight loss plan. Future studies exploring the relationship between body fat and injuries should distinguish between individuals who are overfat by Air Force standards, and those who have passed/failed the cycle ergometry fitness evaluation.

Given that 15-20% of active duty members fail the cycle ergometry evaluation each year, monitoring their enrollment in the Fitness Improvement Program, is relevant to future studies. The first phase, *Self Directed Fitness Improvement Program* (SFIP), requires "counseling and development of a conditioning program", and documentation of physical fitness activities for up to 180 days (AFI 40-501, 2001, p.34). If, at the end of the six-month SFIP, the servicemember fails the fitness evaluation, s/he is enrolled in a mandatory, supervised exercise program called the *Monitored Fitness Improvement Program* for an additional six months (AFI 40-501, 2001, p.35). The Fitness Program Office Database maintains records of these individuals in terms of their cycle ergometry results, but does not record final disposition for those who may have failed the fitness test at the end of MFIP. Like those enrolled in the Weight Management Program, individuals enrolled in SFIP or MFIP are required to participate in physical fitness activity and

thus, their exposure to these activities may place them at differential risk for injury than those who pass the annual evaluation and are not overfat. This is important aspect of future studies that examine the relationship of CR fitness with injuries.

Data regarding prior history of injury would permit researchers to distinguish between risks for injuries resulting from an initial injury from previous injuries. While obtaining data is possible for injuries sustained while on servicemembers were on active duty, it is nearly impossible for individuals recently accessed by the USAF whose historical medical data is nonexistent or sparse. Additionally, risk factors for acutely acquired injuries are different from risk factors for injuries resulting in chronic anatomical or physiological insults (Conway and Cronan, 1992; Jones, et al, 1993; Deuster et al., 1997; Baldry Currens JA, Coats TJ, 2000; Schneider et al., 2002). Therefore, future research should consider separate analyses for examining the relationship of cardiorespiratory fitness with acute versus chronic injuries.

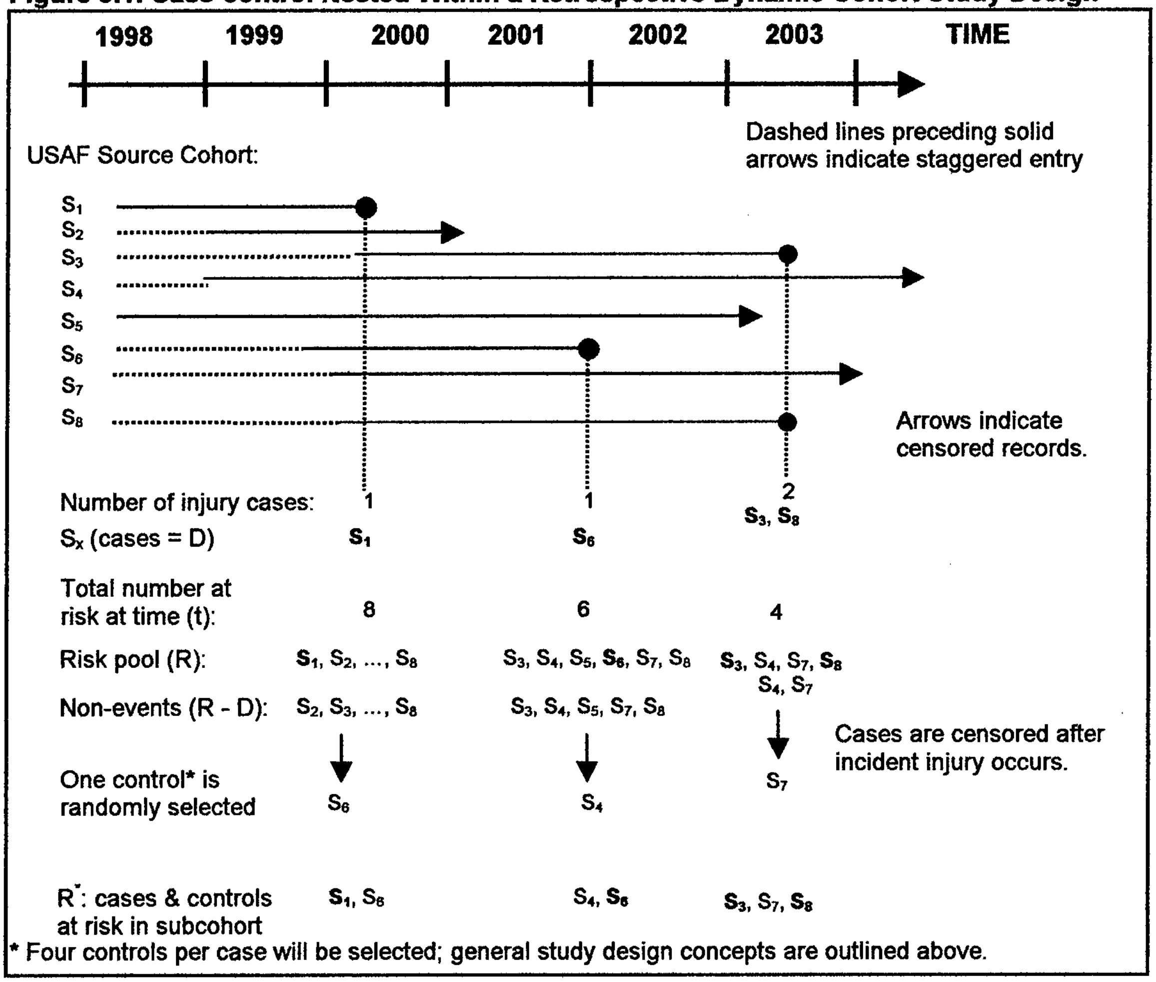
Study Design

This study attempted to address the specific aims and answer broad research questions using a case-control design. Coordinating the linkage of the administrative databases, investigating numerous injury diagnoses, a wide array of covariates, and appropriately categorizing injury outcomes were among the objectives of this study. Using basic measurement and analytic techniques, this is the first study of how, if at all, CR fitness levels are related to injury among active duty USAF personnel. The following suggestions should be considered when attempting to verify the findings and may further explicate the role of CR fitness on injury outcomes.

Employing a case-cohort nested within a retrospective cohort study design would permit researchers to fully explore whether the time-dependent relationship of CR fitness risk factors predict injuries described by Hosmer and Lemeshow (Hosmer and Lemeshow, 1999). The risk set (i.e., source cohort) would be comprised of those ADAF airmen alive at the time of the cases' nonfatal injurious event. Cases would be selected from the DMSS and AFSC databases by applying the criteria for inclusion described earlier. Four randomly chosen ADAF controls alive at

the time of the cases' injurious event would be drawn from the DMSS, and controls could be matched to the case on self-reported tobacco use and exercise frequency to control for their confounding effects on injuries, or left unmatched. The primary requirements for inclusion of cases and their comparison population in this study design would be that each airman must have been on active duty for at least one year and had a cycle ergometry fitness evaluation prior to the cases' nonfatal injury within the study period, 2000 – 2003. Figure 5.1 illustrates the proposed nested case-cohort study design.

Figure 5.1. Case-control Nested Within a Retrospective Dynamic Cohort Study Design



Adapted from Munoz A, *Cohort Studies: Design, Analysis, and Applications Course* (340.603.01), Johns Hopkins University Bloomberg School of Public Health, 2004.

Analysis

The nested case-cohort design dictates analytic techniques that differ substantially from that of the case-control study. Cox proportional hazards regression models would be fitted to detect and control for confounding by unmatched independent variables on the dependent variables of interest as described by Hosmer and Lemeshow (Hosmer and Lemeshow, 1999). Given the low frequency rates of injuries (i.e., they are rare events) in the proposed study, the relative odds of CR fitness exposure would yield a reasonable approximation of the relative risk of injury given differential CR fitness levels. Furthermore, separate multiple linear regression models could be fitted to explore the relationships between CR fitness and the number of duty days lost, and the length of stay in a hospital, and thereby address injury severity.

Policy

The Air Force leadership recognizes and promotes the value of a healthy workforce in carrying out its various missions. However, its policies toward injury prevention and control as it relates to physical fitness are fragmented. On the one hand, fitness is encouraged, but there is little oversight as to how fitness regimens should be carried out for individuals with differential CR fitness levels until an active duty member has failed his/her fitness evaluation or if a person has been found to be overfat.

Additionally, failing the fitness evaluation and/or enrollment in the Weight Management Program can and does result in administrative punishments that place less fit individuals at a disadvantage. In those circumstances, individuals may take up fitness routines that place too much biomechanical stress on anatomic locations (i.e., joints and lumbar spine) that result in injury. Furthermore, the policies do not address proper fitness attire (e.g., appropriate running shoes, wind/rain suits, etc.) and the Air Force makes no provisions for those individuals occupying the lower economic strata of its force (i.e., the most junior enlisted personnel).

E-codes for medical encounters involving injuries are nonexistent in military medical databases and the data fields for STANAG codes are woefully incomplete (less than 2% of the cases requiring hospitalization in this study had a STANAG code). Also, reportable mishaps that

should be recorded in the AFSAS represent approximately 35% of injury events that should be reported (Copley BC, telephone interview, 2004). Without proper safety investigations for reportable mishaps (i.e., injury surveillance), understanding the full spectrum of the nature of the injury event hampers understanding where injury prevention and intervention efforts may be best placed.

Combining fitness and weight management into one policy would be a logical starting point that could benefit the active duty force, individually and collectively. Individuals who are overfat and/or fail the fitness test require oversight from an exercise physiologist that differ from the needs of individuals capable of maintaining weight and fitness standards. It is not uncommon to find that overfat individuals have lower cycle ergometry scores than their less fat counterparts. Also, lower CR fitness levels and high body fat percentages are associated with other untoward health effects (i.e., poor cardiovascular health). A single policy that addresses the individual from a holistic perspective may facilitate improvement in weight and CR fitness level, simultaneously.

Providing proper physical fitness education and equipment is another facet for policy makers to consider. The Air Force could model a fitness program after the US Army's weekly physical fitness regimen where members of the unit meet three days a week to train together. At the start of the physical fitness training, equipment checks for proper functioning (e.g., checking shoes for wear and ensuring that everyone is properly attired), and instruction on how to properly exercise could be carried out.

When and how safety investigations are to be carried out are already explicitly stated in the Air Force Instruction governing them, so there is no need to restate the policy. Enforcing the current policy is the crux of the problem. This could be accomplished by sending weekly medical reports for all injuries to unit commanders as well as base safety, and tracking completed investigations through the Air Force Occupational Safety and Health Council meetings.

Conclusion

This case-control study explored the relationship of cardiorespiratory fitness to unintentional nonfatal injuries in the USAF population. The linkage of military databases with cardiorespiratory fitness data and acute nonfatal injury medical visits, irrespective of where they occurred, offered a unique opportunity for capturing a variety of unintentional nonfatal injuries to USAF active duty personnel. The results showed a consistent relationship that higher levels of CR fitness were associated with more injuries among study participants. These results should provide a basis for directing primary and secondary prevention efforts at reducing the burden of unintentional nonfatal injuries among the military and direct future research efforts.

APPENDIX A

List of Acronyms

ACC	Air Combat Command
ADAF	Active Duty Air Force
ADS	Ambulatory Data System
AETC	Air Education and Training Command
AFB	Air Force Base
AFI	Air Force Instruction
AFMC	Air Force Material Command
AFMOA	Air Force Medical Operations Agency
AFMSA	Air Force Medical Support Agency
AFPAM	Air Force Pamphlet
AFPC	Air Force Personnel Center
AFPD	Air Force Policy Directive
AFSAS	Air Force Safety Automated System
AFSC	Air Force Specialty Code (Occupational category)
AFSOC	Air Force Special Operations Command
AFSPC	Air Force Space Command
ASIS	Abbreviated Severity of Injury Scale
AMC	Air Mobility Command
AMSA	Army Medical Surveillance Activity
BCT	Basic Combat Training
BMI	Body Mass Index (anthropometric measure: kg/m^2)
BMT	Basic Military Training
BSC	Biomedical Sciences Corps
CDC	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CHCS	Composite Health Care System (versions: I and II)
CY	Calendar Year, 1 January to 31 December
DC	Dental Corps
DHHS	Department of Health and Human Services
DMDC	Defense Manpower Data Center
DMED	Defense Medical Epidemiology Database
DMSS	Defense Medical Surveillance System
DOB	Date of Birth
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDI	Department of Defense Instruction
DOR	Date of Rank
DRG	Diagnosis Related Group

DTIC	Defense Technical Information Center
EMS	Emergency Medical Service
FPO	Air Force Fitness Program Office
FY	Fiscal Year, 1 October to 30 September
GOV	Government Owned Vehicle
HQ	Headquarters
HRA	Health Risk Appraisal
ICD-CM	International Classification of Disease – Clinical Modification
ICD-E	International Classification of Disease, External Cause of Mechanism of Injury
JAG	Judge Advocate General
LAF	Line of Air Force
LOC	Loss of Consciousness
LOD	Line of Duty
LOS	Length of Hospital Stay
MAJCOM	Major Command
MC	Medical Corps
MEB	Medical Evaluation Board
MSC	Medical Services Corps
MTF	Medical Treatment Facility
NATO	North Atlantic Treaty Organization
NBI	Non-battle Injury
NC	Nurse Corps
NEC	Not Elsewhere Coded
NIOSH	National Institute for Occupational Safety and Health
Non-LAF	Non-Line of Air Force
NOS	Not Otherwise Specified
OPHSA	Office for Prevention and Health Services Assessment
OSD	Office of the Secretary of Defense
OSHA	Occupational Safety and Health Administration
OSI	Office of Special Investigations
PACAF	Pacific Air Command Air Force
PEB	Physical Evaluation Board
POV	Privately Owned Vehicle
PPE	Personal Protective Equipment
RTD	Return To Duty
SADR	Standard Ambulatory Data Record
SECAF	Secretary of the Air Force
SECDEF	Secretary of Defense
SF	Standard Form
SIDR	Standard Inpatient Data Record
SSN	Social Security Number
STANAG	NATO Standardization Agreement for the coding of the external causes for DoD hospitalizations

TAIHOD	Total Army Injury and Health Outcomes Database
TIG	Time in Grade
TIS	Time in Service
USA	U.S. Army
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAF	U.S. Air Force
USAFA	United States Air Force Academy
USAFE	United States Air Force Europe
USAFSC	United States Air Force Safety Center
USMC	U.S. Marine Corps
USN	U.S. Navy
VO_{2max}	Maximum Aerobic Capacity (ml/kg/min)

APPENDIX B

Codebook of Variables

```
codebook caco
------------------------------------------------------------------------------
caco                                                        Case -vs- Control
------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [0,1]                       units:  1
         unique values:  2                       missing .:  0/72730

            tabulation:  Freq.  Value
                         33042  0 "Control"
                         39688  1 "Case"

codebook sex
------------------------------------------------------------------------------
sex                                                                     Gender
------------------------------------------------------------------------------
                  type:  string (str1)

         unique values:  2                      missing "":  0/72730

            tabulation:  Freq.  Value
                         13496  "F" FEMALE
                         59234  "M" MALE

codebook age_event
------------------------------------------------------------------------------
age_event                                                            Age (yrs)
------------------------------------------------------------------------------
                  type:  numeric (float)

                 range:  [17.876713,61.715069]       units:  1.000e-06
         unique values:  11054                   missing .:  0/72730

                  mean:   30.374
              std. dev:  7.75242

           percentiles:        10%       25%       50%       75%       90%
                           21.0466    23.611   29.0247    36.874   40.9507
```

```
codebook agegrp8
------------------------------------------------------------------------------
agegrp8                                                             Age Groups
------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [1,8]                        units:  1
         unique values:  8                        missing .:  0/72730

           tabulation:  Freq.  Value
                         6879  1 "17 - 20 yrs"
                        20796  2 "21 - 25 yrs"
                        13989  3 "25 - 30 yrs"
                        11003  4 "31 - 35 yrs"
                        12934  5 "36 - 40 yrs"
                         5272  6 "41 - 45 yrs"
                         1491  7 "46 - 50 yrs"
                          366  8  ">51 yrs"

codebook ethnic
------------------------------------------------------------------------------
ethnic                                                           Ethnic Groups
------------------------------------------------------------------------------
                  type:  string (str9)

         unique values:  6                        missing "":  0/72730

           tabulation:  Freq.  Value
                          529  "Am Indian"
                         2206  "Asian"
                        10948  "Black"
                         7899  "Hispanic"
                         1500  "Other"
                        49648  "White"


codebook edcat
------------------------------------------------------------------------------
edcat                                                       Level of Education
------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [1,5]                        units:  1
         unique values:  5                        missing .:  0/72730

           tabulation:  Freq.  Value
                         6101  1 "High School/GED"
                        50369  2 "Some College"
                         8718  3 "Bachelor Degree"
                         5919  4 "Master Degree"
                         1623  5 "Professional/PhD"
```

```
codebook rankcat
-------------------------------------------------------------------------------
rankcat                                                         Rank Categories
-------------------------------------------------------------------------------
                  type:  string (str7)

         unique values:  5                        missing "":  0/72730

           tabulation:  Freq.  Value
                        14903  "E1 - E3"
                        36553  "E4 - E6"
                         8150  "E7 - E9"
                         7802  "O1 - O3"
                         5322  "O4 - O6"

codebook marstatcat
-------------------------------------------------------------------------------
marstatcat                                                       Marital Status
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [0,2]                        units:  1
         unique values:  3                        missing .:  0/72730

           tabulation:  Freq.  Value
                        45687  0 "Married"
                        21893  1 "Single"
                         5150  2 "All Else"

codebook lafnlaf
-------------------------------------------------------------------------------
lafnlaf                                                          LAF -vs- NLAF
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [0,1]                        units:  1
         unique values:  2                        missing .:  0/72730

           tabulation:  Freq.  Value
                        64134  0 "LAF"
                         8596  1 "NLAF"

codebook newtestres
-------------------------------------------------------------------------------
newtestres                                          Pass -vs- Fail Ergo Result
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [0,1]                        units:  1
         unique values:  2                        missing .:  0/72730

           tabulation:  Freq.  Value
                        11267  0 "Fail"
                        61463  1 "Pass"
```

```
codebook tobyn
-------------------------------------------------------------------------------
tobyn                                                Tobacco Use (No -vs- Yes)
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [0,1]                        units:  1
         unique values:  2                        missing .:  0/72730

            tabulation:  Freq.  Value
                         51793  0 "No"
                         20937  1 "Yes"

codebook tobcat
-------------------------------------------------------------------------------
tobcat                                                  Tobacco Use Categories
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [1,5]                        units:  1
         unique values:  5                        missing .:  0/72730

            tabulation:  Freq.  Value
                         51793  1 "None"
                         15775  2 "Cigarettes"
                          3039  3 "Smokeless"
                           999  4 "Pipes/Cigars"
                          1124  5 "All Combos"
```

USAF Major Command

USAF Major Command	Freq.	Percent	Cum.
ACC	19,280	26.51	26.51
AETC	11,207	15.41	41.92
AFMC	7,258	9.98	51.90
AFSOC	1,963	2.70	54.60
AFSPC	3,928	5.40	60.00
AMC	11,823	16.26	76.25
HQ/DRU/FOA/OTHER	6,133	8.43	84.69
PACAF	6,103	8.39	93.08
USAFA	490	0.67	93.75
USAFE	4,545	6.25	100.00
Total	72,730	100.00	

```
codebook new_bmi
-------------------------------------------------------------------------------
new_bmi                                                             BMI (kg/m2)
-------------------------------------------------------------------------------
                  type:  numeric (float)

                 range:  [15.033832,50.721424]        units:  1.000e-06
         unique values:  12355                    missing .:  0/72730

                  mean:   25.3588
              std. dev:   3.32696

           percentiles:        10%       25%       50%       75%       90%
                              21.1   23.0661   25.3051   27.4629   29.4925
```

```
codebook bmicat
-------------------------------------------------------------------------------
bmicat                                                      NIH BMI Categories
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [1,4]                        units:  1
         unique values:  4                        missing .:  0/72730

           tabulation:  Freq.   Value
                        29598   1 "Normal Weight"
                         3614   2 "Underweight"
                        33704   3 "Overweight"
                         5814   4 "Obese"
codebook score
-------------------------------------------------------------------------------
score                                                      VO2 max (ml/kg/min)
-------------------------------------------------------------------------------
                  type:  numeric (byte)

                 range:  [15,80]                      units:  1
         unique values:  66                       missing .:  0/72730

                  mean:   37.5659
              std. dev:   7.93759

           percentiles:        10%       25%       50%       75%       90%
                                28        32        37        42        48
```

Anatomic Location of Injury

anatinj	Freq.	Percent	Cum.
No Injury	33,042	45.43	45.43
ankle/foot/toes	4,489	6.17	51.60
body unspecified	7,598	10.45	62.05
eye	906	1.25	63.30
face/head/neck	1,753	2.41	65.71
hip/leg	3,127	4.30	70.01
knee	2,816	3.87	73.88
shoulder/arm	4,701	6.46	80.34
spinal column	9,757	13.42	93.76
thorax/abdomen	714	0.98	94.74
wrist/hand/fingers	3,827	5.26	100.00
Total	72,730	100.00	

Nature of Injury Categories

TRAUMATIC BEAIN INJURY (TBI)

natureinj	Freq.	Percent	Cum.
TBI	135	58.70	58.70
concussion/coma	85	36.96	95.65
contusion	2	0.87	96.52
fracture	4	1.74	98.26
open wound/laceration	4	1.74	100.00
Total	230	100.00	

SUPERFICIAL INJURY

natureinj	Freq.	Percent	Cum.
abrasion	305	8.95	8.95
blister	43	1.26	10.22
contusion	1,937	56.87	67.09
insect bite	452	13.27	80.36
superficial injury	669	19.64	100.00
Total	3,406	100.00	

BURN

natureinj	Freq.	Percent	Cum.
burn	222	100.00	100.00
Total	222	100.00	

TRAUMATIC INJURIES

natureinj	Freq.	Percent	Cum.
amputation	8	6.40	6.40
crush injury	50	40.00	46.40
rupture	67	53.60	100.00
Total	125	100.00	

REPETITIVE TRAUMA DISORDERS (RTD)

natureinj	Freq.	Percent	Cum.
RTD	1,314	25.75	25.75
bursitis	295	5.78	31.53
enthesopathy	1,140	22.34	53.87
flat foot/fibromatosis	746	14.62	68.49
myalgia/neuritis	1,066	20.89	89.38
neck/back injury	158	3.10	92.48
tendinitis	384	7.52	100.00
Total	5,103	100.00	

ENVIRONMENTAL EFFECTS

natureinj	Freq.	Percent	Cum.
contusion	1	0.12	0.12
environmental effects	538	63.07	63.19
hearing loss	314	36.81	100.00
Total	853	100.00	

FOREIGN BODY

natureinj	Freq.	Percent	Cum.
foreign body	422	100.00	100.00
Total	422	100.00	

FRACTURE

natureinj	Freq.	Percent	Cum.
fracture	1,688	100.00	100.00
Total	1,688	100.00	

OPEN WOUND

natureinj	Freq.	Percent	Cum.
contusion	2	0.09	0.09
open wound/laceration	2,319	99.91	100.00
Total	2,321	100.00	

JOINT CONDITIONS

natureinj	Freq.	Percent	Cum.
dislocation	857	11.95	11.95
jt derangement	1,015	14.15	26.09
jt pain/effusion	4,859	67.73	93.82
neck/back injury	11	0.15	93.98
tear/disruption/loose body	383	5.34	99.32
traumatic arthropathy	49	0.68	100.00
Total	7,174	100.00	

LUMBAGO/BACKACHE

natureinj	Freq.	Percent	Cum.
lumbago/backache	7,165	97.90	97.90
neck/back injury	154	2.10	100.00
Total	7,319	100.00	

SPRAINS

natureinj	Freq.	Percent	Cum.
sprains	9,696	100.00	100.00
Total	9,696	100.00	

INJURY UNSPECIFIED

natureinj	Freq.	Percent	Cum.
contusion	6	0.53	0.53
injury unspecified	1,123	99.47	100.00
Total	1,129	100.00	

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CURRICULUM VITAE

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ACADEMIC TRAINING

PhD – Injury Epidemiology. The Johns Hopkins University, Bloomberg School of Public Health, Baltimore MD.

MPH – Epidemiology. Uniformed Services University of Health Sciences, Bethesda MD.

DVM – General Practice. Oregon State University Veterinary Medical School, Corvallis OR.

BA – Biology. The Evergreen State College, Olympia WA.

RESEARCH EXPERIENCE

Doctoral Student, Injury Epidemiology, Center for Injury Research and Policy, The Johns Hopkins University, Bloomberg School of Public Health, Baltimore MD (September 2002 – October 2005)

- Sponsored by the Air Force Institute of Technology for doctoral-level training in injury control, prevention and epidemiology.

- Conducted epidemiological research on the association of cardiorespiratory fitness with unintentional nonfatal injuries among the active duty Air Force population.

Masters Student, Epidemiology, Uniformed Services University of Health Sciences, Bethesda MD (July 1999 – June 2000)

- Sponsored by the Air Force Institute of Technology for masters-level training in epidemiology.

- Conducted epidemiological research on combat training exercise-related injuries among the active duty Air Force population.

APPLIED PUBLIC HEALTH EXPERIENCE

USAF Public Health Officer, Assistant Chief – Flight Commander, USAF Public Health Assignments: McClellan AFB, CA; Osan AB, Korea; Onizuka AB, CA; Brooks AFB, TX (February 1993 – September 2002)

- Managed multiple primary and secondary Public Health prevention and control programs. Programs covered: reportable infectious disease surveillance and prevention; environmental sanitation; food safety and hygiene; occupational health and safety; medical entomology; medical employee health; and military medical intelligence.
- Supervised and led all personnel assigned at base-level.
- Interfaced with US Army, US Navy and civilian sector regarding all aspects of military public health at all installations.

TEACHING EXPERIENCE

USAF Public Health Officer – Chief, Occupational Health Branch; USAF School of Aerospace Medicine, Brooks AFB, TX (July 2000 – July 2002).

- Instructor. Subject matter expert for instructional blocks in occupational health and safety. Oversaw courses that award the entry-level AFSC to enlisted and officer members in the medical career fields of Aerospace Medicine and Public Health.
- Course Supervisor: Public Health Officers Course -- Directed the development and delivery of courses that prepare new officers to perform their career field duties at their first bases.
- Served as a career mentor and supervisor to nine Aerospace Medicine technicians and one Public Health technician.

Adjunct Faculty – Biology, Anatomy and Physiology, and Zoology; University of Alaska – Anchorage; Anchorage AK (September 1989 – May 1990; September – December 1992)

- Developed and delivered instruction in Biology, Anatomy and Physiology, and Zoology courses for undergraduates in the laboratory setting.

HONORS AND AWARDS

USAF Meritorious Service Medal	1999, 2000
USAF Commendation Medal	1995, 1996
Public Health Officer of the YearSpace Command	1998

COMPUTER SKILLS

Stata Statistical Software, Statistical Package for the Social Sciences, Microsoft Products: Excel, Word, Access, PowerPoint.